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PREDICTING MILK DELIVERIES IN ALBERTA

University — Université: UNIVERSITY OF ALBERTA

Degree for which thesis was presented — Grade pour lequel cette thèse fut présentée: MASTER OF SCIENCE

Year this degree conferred — Année d'obtention de ce grade: FALL, 1980

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PREDICTING MILK DELIVERIES IN ALBERTA

by

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A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE
IN
AGRICULTURAL ECONOMICS

DEPARTMENT OF RURAL ECONOMY

EDMONTON, ALBERTA
FALL, 1980

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled PREDICTING MILK DELIVERIES IN ALBERTA submitted by TERRANCE JAMES APPLEBY in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in AGRICULTURAL ECONOMICS.

Leonard Bauer

Supervisor

Date January 11, 1980

ABSTRACT

This study developed and compared four econometric models for accuracy and ease of use in predicting milk deliveries in Alberta for the time period November 1978 to June 1979. Two of the models were designated as Complex models and were developed by initially segregating dairy herds into five unique producer categories and then using ordinary least squares techniques to estimate the parameters for each month's predictive equations. One of these models was designated as a Complex Stage-of-Lactation model and was developed from data encompassed in the Cow Master file of the Dairy Herd Improvement (DHI) program. The other model was referred to as a Complex Cows-in-Milk model and was developed using data encompassed in the Herd Master file of the same program. The other two models were designated Simplified Stage-of-Lactation and Simplified Cows-in-Milk and were developed from a smaller sample base and irrespective of producer category.

Monthly delivery schedules were compared over the 12 month period July 1978 to June 1979 to allow herd comparisons between DHI and non DHI herds for each category. Monthly delivery and production totals over the same time period were compared to assess the proportion of milk produced that was actually delivered to dairy plants.

Total milk delivered in Alberta for a month under investigation was estimated to be the product of (a) predicted production per category per month for DHI herds,

(b) the number of herds in each category, (c) the monthly production coefficient, and (d) the monthly herd delivery coefficient.

The Complex models were found to predict deliveries to within 2% of actual milk delivered and the Simplified models had an average 5.5% predicted error when the two model designations were compared over the same time period used in their development. Due to present data limitations the Complex Cows-in-Milk model was chosen as most appropriate for further research and completion of the model for year around usage.

ACKNOWLEDGEMENTS

I am deeply indebted to a number of people for the assistance and help they have given me in the undertaking and completion of this work. I greatly appreciate in particular the direction that my advisor Dr. Len Bauer gave me in developing the topic and for the timely advice he gave me from time to time. I was fortunate to have a person of his calibre as my advisor. To my committee members Dr. M. M. Lerohl, Mr. Wayne Anderson, and Mr Jim Gylander of the Alberta Dairy Control Board go a special thanks for their advice and assistance in pointing out some of the studies limitations. Another person I wish to acknowledge is Mr. Gordon Grosch of Alberta Agriculture who supplied the research topic and kindly supplied much of the underlying data used in its development. Knowing that the study would be of benefit to someone when it was completed made it much more challenging to tackle. Other people in Alberta Agriculture I wish to recognize are Mr. Darwin Daviduk and Keith Toogood of Systems Design and Data Analysis. Darwin ably assisted in the collection of the DHI tapes that formed the base of this study and Keith was helpful in supplying much of the Alberta Dairy Control Board information. To Claire Shier and Jim Copeland of Rural Economy a special thanks for the computer assistance given in the analysis. Most importantly I wish to thank my wife Christie who offered encouragement when things didn't seem to be going too well and also was patient in the face of numerous

evenings that required time away from home. To Marc and Jeff, my 2 and 4 year old sons, a very special thanks as well for the opportunity to slip away to work evenings when they should have seen more of Daddy.

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I. INTRODUCTION

A. The Problem

In recent years Alberta dairy policy makers have faced the problem of increasing Alberta's total milk production and increasing Alberta's share of industrial milk produced at the national level. In 1978 this national share amounted to approximately 7%[1] but a buoyant provincial economy has made the goal of increased production and increased market share a major concern for the 1980s.[2]

Alberta dairy policy, whether from an explicit or implied point of view, has always been attempting to increase provincial milk production. Over the years these attempts have been made in the face of declining yearly production and increasing average production per cow.[3] Today cow numbers in Alberta number 142,000 (excluding dairy heifers), a drop of 4% from that of 1978. Figure 1.1 visually shows this continuing drop in cow numbers. With Alberta's population increasing at approximately 3%[4] and per capita fluid milk consumption increasing by over 5%[5] the search for a stimulus to increase dairy production to cover provincial consumption is felt to be strongly needed.

---

[1] Dairy Farmers of Canada 1979 Dairy Facts and Figures at a Glance Ottawa May 1979 Table 23

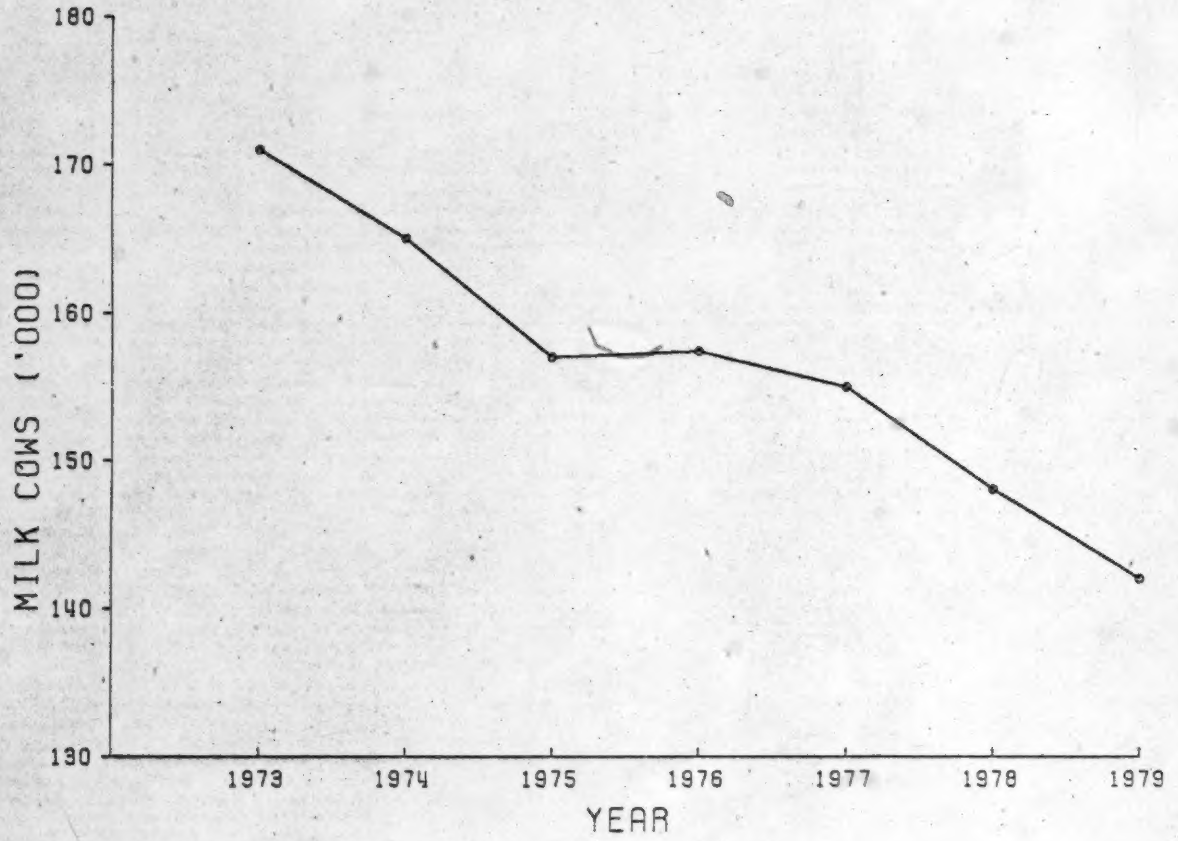
[2] Alberta Agriculture Alberta Dairy Situation and Outlook Market Analysis Analysis Branch April 1979 p1

[3] Ibid, Table 8 and Table 5

[4] Agriculture Canada Handbook of Food Expenditures, Prices and Consumption Ottawa April 1979 Table 2 pp 5 6

[5] Alberta Agriculture Alberta Dairy Situation and Outlook Market Analysis Branch February 1979 Table 4 p3

Figure 1.1 Number of Dairy Cows in the Province by Year



B. Characteristics of the Alberta Dairy Industry

Although the dairy industry in Alberta does not play a major role in the structure of the Alberta agricultural scene it is one industry that offers highly stable production of an important commodity. In 1976 Alberta had 1745 commercial farmers who produced 581.3 thousand tonnes of milk.[6] By 1978 production had fallen to 577.3 million tonnes after reaching 584.7 tonnes in 1977.[7] Thus milk production fluctuated little over the 3 year period. On a farm receipt basis, Alberta's dairymen received 8% of the cash receipts of Alberta producers for livestock and livestock products and 5% of the total farm cash receipts of Alberta agricultural producers.[8]

The increase in the dairy heifer population to 31,000 (a 6.9% increase from that of 1978) should have been an encouraging sign for dairy policy planners. However, in spite of this increase, the milk cow-heifer ratio rose to 4.6 versus the ratios of 4.3 and 4.1 for 1977 and 1978 respectively. This increase in the ratio suggests a depletion in the number of replacement cows and could be signalling future declines in both dairy cow numbers and milk production. As well this higher ratio could be due to rising feeder cattle prices which makes more stringent herd culling and the raising of dairy heifers for beef purposes financially feasible. To counteract these possible detrimental circumstances a number of recent policy changes have been made.[9] Unfortunately it is difficult to assess the dairy industry's response to the changes because there is no reliable system of measurement to assess dairymen's plans for expanding herd sizes, increasing average herd production or both.

---

[6] Dairy Farmers of Canada 1979 Dairy Facts and Figures at a Glance Ottawa May 1979 Table 6

[7] Ibid

[8] Statistics Canada Farm Cash Receipts Ottawa February 1979 Vol 39 No 12

This study will attempt to overcome this problem. Data from the Dairy Herd Improvement Program will be used as a base for the development of four econometric milk predicting models. Multiple regression or ordinary least squares analysis will then be used to estimate the coefficients of each model. Since not all herds in Alberta are enrolled on the program, a comparison of milk deliveries to respective plants will be undertaken to compare DHI and non-DHI producers for a common type of shipment. This data is compiled monthly by the Alberta Dairy Control Board. The proportion of milk produced that was actually delivered will be determined since the supply of milk in Alberta is measured by the total deliveries made to dairy plants By accurately predicting milk supply, policy planners should be better able to anticipate the industries response to present dairy policy and make the necessary changes to encourage production.

---

[9] These policy changes will be discussed more fully later on.

The price of milk and the prices of other complementary and competing products will not be used in the development of the models because the dairy industry is highly regulated. Any changes that occurred in these areas in the time period under study will be viewed as being "stochastic" in nature. These models will be an attempt to measure industry response after it has occurred as opposed to a larger and more complex supply response model which usually attempts to measure industry response in relation to a change in one variable, usually the price of milk.

C. Limitations of the Study

This study will be done using data over a short time period. Since DHI data is not stored on a regular basis, the data unique to development of two of the four models could only be obtained on an "as it happens" monthly basis. Hence, DHI data for only the months of November 1978 to June 1979 inclusive were used in this study. Selection of the most appropriate model for continued research will be made from a comparison of the models over this time period.

D. Organization of the Thesis

A discussion of dairy policy at both the Federal and Provincial level follows in the next chapter. It also contains an overview of the changes that have been made to current policy and the economic theory that serves as a background to these changes. Chapter 3 contains a review of previous research work done in the area of predicting milk production. An outline of the research methodology used in the development of the four models is the topic of discussion in Chapter 4 and and Chapter 5 contains discussion on the results, accuracy and suitability of the four models involved. The final chapter includes a brief summary of the study, the conclusions drawn and a discussion on the directions for future research.

II. AN OVERVIEW OF GOVERNMENT DAIRY POLICY

Canadian dairy policy affects all sectors of the dairy industry from the farm production of milk to international trade in processed dairy products. The primary goal of practically all dairy policy, whether under federal or provincial jurisdiction, has been to encourage long term viability in the domestic dairy industry so that domestic consumption of dairy products may continue to be met predominantly from Canadian production. The most appropriate avenues of promoting this viability were perceived to be stable farm prices, with consequent reduction in risk, and a sufficient level of returns to encourage dairy enterprises to be efficient and adopt new cost saving technology. As D. Peter Stenhouse notes:[10]

> "It is doubtful whether the dairy industry would be such a prominent sector of the Canadian economy without extensive government intervention."

A. The Role of the Federal Government

At the Federal level, dairy policy translates into a set of regulations that control supplies and gross returns for industrial milk and cream used in the manufacture of butter, cheese and other processed dairy products. The policy instruments used by the federal government to achieve these goals include the following:

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[10] Stenhouse D. P. Government Policies for the Canadian Dairy Industry Canadian Farm Economics Vol 14 No 1-2 February-April 1979 p1

1. offers to purchase processed products at minimum guaranteed prices so that processing plants can pass on some of the benefits of higher and more stable prices to producers,
2. direct subsidies to producers to increase the returns for manufactured milk and lower the price to the consumer,
3. partially subsidizing any export of surplus processed products such as skim milk powder,
4. discriminatory pricing, and import tariff and non-tariff barriers in order to stabilize or increase prices, and
5. quotas, penalties and holdbacks to manage the supply of milk coming onto the market.

These five major areas of policy involvement are administered by the Canadian Dairy Commission (CDC), an agency established under the Dairy Commission Act of 1967.The Commission has implemented a complex system of regulations in order to achieve the first three policy objectives. offering to purchase dairy products at a stipulated price, and with manufacturers having to compete for milk to maintain their plant operations, these guaranteed prices in effect have become minimum prices for all industrial milk. To arrive at the price the producer will receive, an assumed processors margin is subtracted from this guaranteed price to obtain an "estimated producers market return". This return coupled with a subsidy of $2.66 per hundredweight (cwt) of milk equals the CDC target support price.[11] For the 1979-1980 dairy year this price will amount to $13.29.[12] On April 1, 1975 this target support price was indexed with the price being determined by a weighting of cash input prices, the consumer price index and a number of judgemental factors. The weightings were 45%, 35% and 20% respectively.[13]

Policy objective 4 listed earlier is pursued by restricting the import of dairy products into Canada, mainly specialty cheese.[14] Butter is imported by the CDC to stabilize domestic prices which fluctuate substantially in response to domestic supply conditions. Since dairy products are on the import control list, a permit is required for any importation. Thus direct control of any imports is possible by the Federal government. Exports of dairy products are supported by levies assessed on the producers of industrial milk.[15] These levies are paid into an export equalization fund.

Policy objective 5, the use of quotas, holdbacks and penalties to manage the supply of milk, has undergone substantial changes since first becoming part of the Comprehensive Milk Marketing Plan in 1970. Under this plan, the Canadian Milk Supply Management Committee (a committee composed of representatives of each of the provinces and the CDC) uses a program encompassing market share quota (MSQ) to regulate the Canadian milk supply and to provide a balance between domestic production and use of butterfat in manufactured products. These quotas are allocated to individual producers based on the producers production level during the previous year. For the coming dairy year (August 1, 1979 to July 31, 1980) the total Canadian requirements for milk has been projected to be 98 million hundredweights of milk and with a 5% sleeve allowed to ensure this supply, 103.7 million hundredweights of MSQ have been allotted. The sleeve represents production that is surplus to demand but needed to ensure this amount of production is forthcoming. To ensure against surplus supply, individual producers who exceed quota allottment will be subject to an over quota levy or penalty of $8.00. A further continguency levy of 25¢ per cwt will be collected on all in-quota production to cover any disposal costs associated with the in-sleeve or 5% surplus production that ultimately may prove surplus to Canadian requirements. It is refundable to any individual producer at the end of the dairy year if he has not produced in this sleeve or if production into the sleeve is needed to meet Canadian requirements.[16]

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[11] For a more extensive breakdown of payoff calculations see Appendix 1

[12] Canadian Dairy Commission National Dairy Program 1979-1980 Ottawa March 1979

[13] A price increase was triggered by the index for the fall of 1978 but was delayed until the spring of 1979 as a result of the Federal government exercising its option under this judgemental factor.

[14] In 1978 cheese accounted for approximately 94% of dairy imports

[15] For the 1979-80 dairy year this will amount to $1.00 per cwt and 20¢ per cwt on fluid milk (class 1 milk).

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[16] A more extensive review of Canadian dairy policy can be obtained by consulting the Stenhouse and Bray articles cited in the references

B. The Role of the Provincial Government

Responsibility for ensuring the orderly marketing of milk in Alberta rests with the Alberta Dairy Control Board in Wetaskiwin. This Board administers the MSQ aspects of the Federal program, represents Alberta on the Canadian Milk Supply Management Committee and determines production quotas for the manufacture and distribution of fluid milk. Quotas for the fluid market are determined by the projected requirements of the market area. To ensure a constant supply, this requirement is set at approximately 115%-130%[17] of fluid sales with daily quotas allotted to producers to ensure this amount of milk will be forthcoming. Production that is surplus to fluid requirements receives industrial milk payment and subsidy provided sufficient MSQ is held by a fluid producer to cover this surplus production. In recent years the amount of fluid production that has entered or "crossed over" into the industrial milk market has intensified.

In the past 4 years cross over has occurred from the industrial market to the fluid market as well. Industrial milk producers who meet certain sanitation requirements, daily production averages, etc.[18] receive 400 pounds per day of fluid milk quota their first year of entry and 200 pounds

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[17] Although this amount of quota is issued, payoff for any month is based on the level of sales, approximately 85% of quota allotted, with the remainder receiving Class 2 and Class 3 prices.

[18] For a complete list of the requirements for entry see Alberta Dairy Control Board Milk and Cream Quota Policies for the 78-79 Quota Period Wetaskiwin April 1978 p12-14

for each of the next two years. These producers, referred to as graduated entrants, can now receive the higher returns of the fluid producers for this amount of shipment. The ultimate conclusion of this program appears to be one classification or standard for milk with milk utilization determining the payout to any individual dairymen.

C. The Changes in Current Dairy Policy

Alberta dairy policy planners have made four major changes to present policy to stimulate the increased production of milk in Alberta and there is a possible fifth change to come. The first major change was with respect to market share quota. Now

> "all existing milk and cream producers who wish to deliver more than their present quota can do so and the Board will cover such shipments with market share quota from the provincial reserve. This policy is in effect now and will be effective until March 31,1980".[19]

The second major change was to the graduated entry policy. Now

1. application can be made at any time (as opposed to applications being received prior to September 1 for entry January 1st of the following year),
2. dates of entry into the program are now the 1st of January, May and September (as opposed to only January

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[19] Alberta Dairy Control Board Important Information to All Dairy Producers Wetaskiwin February 1979

1),

3. any applicant must now have marketed for two months prior to the date of entry (as opposed to the previous 12 months), a daily minimum production of 500 pounds of milk or milk equivalents. This amount marketed will determine the entrants total quota and will not exceed 800 lbs,
4. all applicants must be able to show that they have not disposed of either fluid quota or quota previously allotted under the graduated entry program during the 24 month period prior to entry, and
5. all applicants now are required to ship to their graduated entry quota for a full two years after final allottment before such quota may be transferred other than as set out in other regulations.[20]

A third change and one yet to take effect is the advising of fluid quota holders that commencing in 1980, September is to be considered as a permanent low month. Previously, the three lowest months of the year when the ratio of total provincial production to fluid sales was lowest, was used to adjust fluid milk quotas.

The fourth major change to policy has taken place in the area of the Alberta Dairy Development Program.[21] A fifth major stimulus to the industry could be the reintroduction of the Dairy Heifer Import program, a program that was in place for 2 years in the mid 1970s.

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[20] Ibid p7-8

[21] See Appendix 2 for complete details of this program.

D. The Economic Theory of Milk Supply

The rationale behind this study and the assumptions implied in making the dairy policy changes listed are all based on underlying economic concepts. In a mixed economy such as Canada's, the prices paid or received for goods and services are set by the forces of supply and demand and therefore subject to the choices and desires of producers and consumers. Within the dairy industry, a free market economy does not totally exist as prices that producers receive for their milk and the prices consumers pay for the product are controlled by Public Utility Boards. In addition, milk quotas act as as barrier to entry into the industry and restrict the supply of milk coming onto the market.

In Alberta these quotas form only one causal variable in determining the aggregate supply of milk. This aggregate supply function can be defined as the relationship between the quantity of milk supplied and those variables that influence that supply. Symbolically such a relationship can be viewed as follows:

$$Q = f(C, T, P, S, I, O, N, R, G)$$

where:

Q = the quantity of milk supplied to the market per time period

C = the number of cows-in-milk per time period

T = the technology employed in producing milk

P = the current price for milk

S = the prices of other products

I = the prices of imports

O = the objectives of dairymen

N = the number of dairy farms in Alberta

R = the size distribution of dairy farmers supplying the market place

G = policy variables (support programs, deficiency payments, quotas, imports, etc.)

In this study the supply function assumes the latter 8 variables to be independent of quantity and any movement of these variables to be stochastic or random in nature. Milk production is therefore theorized to be a function of the number of cows-in-milk in the Province. This relationship is assumed to hold only in the short run since a long run analysis would require the inclusion of the other variables mentioned above. Since no accurate data exists on the total number of cows being milked, a sampling of herds is used to estimate the average production for a herd and then this estimated production is multiplied by the number of herds in the Province.

At the individual farm level this average production is obtained by means of a production function with the number of cows-in-milk as the major input variable. In the ideal economic setting this can be explained as follows. Dairymen combine their major input factors (land, labour, capital and management) to produce milk. Dairy cows as a factor of production form a part of the much larger capital input. If it is assumed that all inputs are fixed with only the number of cows free to vary for a given dairy farm, a relationship exists where milk yield increases as more cows are freshened or added to the milking base. As more and more cows are added, the law of diminishing returns eventually becomes prominent. This law states that as "increasing amounts of one input are added to a production process while all other inputs are held constant, the amount of output added per unit of variable input will eventually decrease." As more cows are added to the herd, adverse effects are felt from other constraints such as management skills, technology, etc. At such a time, the marginal product of cows or the increase in total milk yield with an addition of another cow will be zero. Correspondingly the value of its marginal product will be zero.

This point is the upper boundary at which cows are added to the herd. However before this point is reached, the dairymen would have reacted by altering all or some of the input constraints that were previously assumed constant. The least number of cows which ought to be employed in the herd is that number which results in the highest average product produced per cow. Thus this same dairyman would keep adding cows to his milking base if the additional product that each additional cow contributed was increasing. When the lower boundary point is reached, the additional product each additional cow contributed equals the average product of all the cows. The area bounded by this upper and lower boundary points is referred to as the Stage Two area of the production function and is the only rational area of production.

At the individual dairy cow level, there is an underlying production function unique to each cow. This uniqueness is due to the inherent differences that exist in the productive ability of cows, nutrient requirements, stomach capacities, etc. If two inputs such as grain and hay are viewed, and all other inputs are held constant, a locus of all the combinations of grain and hay could be shown by means of a product curve or isoquant. The tradeoff or rate of technical substitution at which grain is substituted for hay to maintain a given output level is determined by the price ratio between these two inputs. More grain would be substituted for hay if the price of hay was to rise.

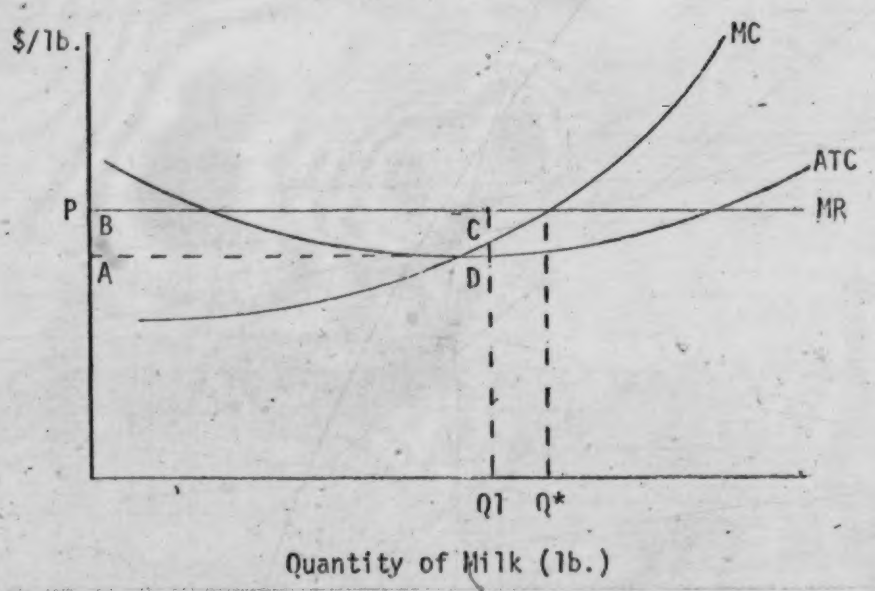
There is also a tradeoff between cows-in-milk and cows-dry at the farm level and this tradeoff coupled with the tradeoff between production inputs for each cow describes the fundamental decisions that face an individual dairyman. The dairymen's optimizing behaviour is to vary the levels of both cost and output so that profit is maximized.

Total revenue is determined by multiplying the market price of milk by the number of hundredweights of milk sold. Costs are computed on the basis of equating the per unit cost of each input in the herd with the value that each input adds to marginal product.

The approach that Alberta dairy policy planners have taken to stimulate the production of milk draws heavily on this optimizing behaviour. The change in market share quota whereby any overproduction will be covered by quota issued by the Alberta Dairy Control Board is an attempt to remove a supply constraint that may have forced some dairy producers to produce at a point where the marginal factor cost was not equal to the value of marginal product.

In an output sense this constraint can be shown as a point where marginal revenue (MR) exceeds marginal cost (MC). Diagrammatically this relationship is shown in Figure 2.1. At price (P) the dairy producer would like to produce Q*, the point where MR equals MC. However quota restrictions allows only the quantity Q1 to be delivered. The area shown as ABCD (the area bounded between the average cost of production and the price of output for quantity Q1) therefore represents the excess profits that accrue to the producer as a result of the enforced underproduction. A result of this action is the capitalization of these future anticipated profits into the value of quota. Removal of the quota restraint should in the long term allow Q* to be attained with its attendant increased milk supply for

Figure 2.1 Milk Production under a Quota Constraint



Albertans.

The easing of requirements for graduated entrant admission allows for increased revenues currently only enjoyed by the fluid milk producer. These higher returns may also induce more producers to enter the industry or convert from cream shippers to milk shippers. The changes made to the Dairy Development Program is also an attempt to lower some of the high costs associated with the industry.

This brief overview of the relevant economic theory not only forms the basis for this study and the recent policy changes but also can be discerned when previous work done on predicting milk is reviewed. This previous work will now be discussed.

III. LITERATURE REVIEW

A. Previous Studies Related to Predicting Milk Production

A number of studies have been undertaken in the area of predicting milk production. They can broadly be classified into two categories; those predicting milk production for an individual cow for use as a farm management tool and those attemping to construct larger more complex models to forecast aggregate milk production (supply response analysis). Each of these study areas have used different approaches to predicting milk production.

B. Predicting Milk Production for Individual Cows

Work involved in predicting milk production for an individual cow and, when aggregated, for a herd has revolved around demonstrating how dairymen could make better management decisions by using partial days in milk records that were extended or extrapolated to 305 days. The most important aspect of predicting at this level has been in estimating the shape of the lactation curve for a particular cow in milk. Extensive work in this area has occurred since the early work of Sanders in 1930. After analyzing nearly 4000 lactations for cows of various breeds and ages he concluded that the curve could be regarded as a combination of four elements: total yield, maximum yield, persistency (or production falloff through time) and spring hump seasonality. Much of the work done to date has substantiated these findings with major work done in showing the shape of the curve and the accuracy and scope with which it can be used. Initial attempts to use the characteristic shape of the lactation curve for predictive purposes involved determining ratio factors to extrapolate 305 day production from part lactations. Lamb and McGilliard (1960) developed such factors to investigate the relative effects of breed, herd, age, parity[22] season of freshening on the relationship between partial and complete lactations. Their findings suggested a difference existed between heifers and older cows. Although this finding was substantiated by later research it was not in complete agreement with the literature of the time. A year later Van Vleck and Henderson used regression analysis to extend partial records to 305 day completion. Their main interest was to show that the accuracy of predictive factors could be improved if intra-herd effects were used in their development although they concluded the extra computational difficulties encountered precluded their use. Other work by Appleman, Musgrave and Morrison (1967) supported these findings. The use of days open and days dry as important influences on the milk production of individual Holsteins was done by Schaeffer and Henderson (1972). They found the relationships accounting for highly variable predictive results difficult to assess due to problems in determining if cows produced poorly due to short open periods or if low producing cows

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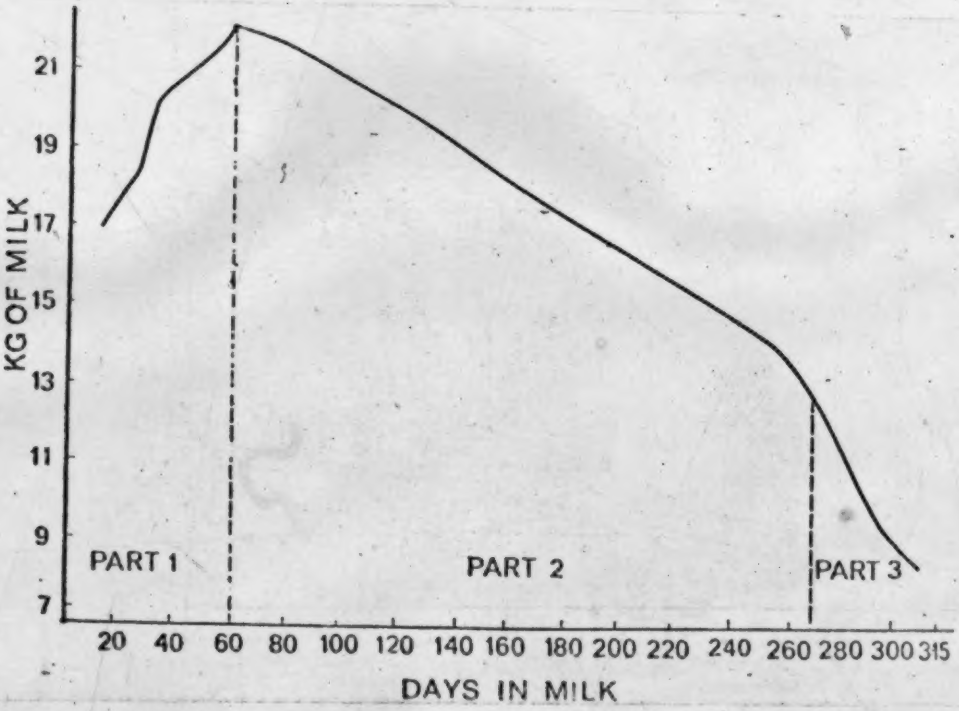
[22] Parity represents the lactation number for a particular cow

received short open periods because of their low milk yield. They also concluded that the effect of days dry and days open on milk production was largely environmental. As a result, adjustments of milk records for days dry was not recommended while adjustment of 305 day records for days open appeared necessary. Applemen et al showed that factors developed by regression analysis were more precise and methods were now being sought to develop more accurate predictive qualities by using the last available test period to project the remaining portion of a cow's lactation. This work was done by Miller in 1973. By 1973 extension factors had progressed to the point where they differed from those currently in use by the United States Department of Agriculture and developed by McDaniel et al (1965). These latter factors had not taken into account season of freshening or age within lactation and had also been developed solely from regional data. Keown and Van Vleck (1973) developed the most involved piece of research work into predicing milk production for an individual cow. They initally took a lactation curve and divided it into 19 segments. Superimposing three season groupings and two ages for each of the first three lactions and a single age for all lactations of four years and over, they were able to calculate average daily milk yield for 114 season-age-stages using multiple regression. Using this procedure they depicted the lactation curve as having three distinct parts. Part 1 showed a production pattern increasing as a decreasing rate up to peak production which occurred between 50 - 60 days in milk. Part 2 showed production decreasing at a nearly constant rate once the peak had been passed. Part 3 displayed a shape to the curve that decreased at an increasing rate. Figure 3.1 reflects these findings. They also found that cows that calved earlier did not peak as high as older cows calving for the same season. The season factor was also found to be important as cows that calved in the first four months of the year reached a higher peak in production. The last four months of the year were found to result in the lowest peak production. These three distinct areas of the lactation curve substantiated the work of Wood (1969) and the work he had conducted as a member of the British Milk Marketing Board in Surrey, England. His earlier work had included the fitting of a logarithmic mathematical function to the shape of the lactation curve.

Perhaps the most questionable work done in estimating the shape of lactation curves was that done by Kellogg, Urquhart, and Ortega (1977). Using Wood's mathematical model for expressing the lactation curve they used regression analysis to test the goodness of fit with data obtained from 73 Holsteins in each of the first four lactations. However they tested the goodness of fit after they had averaged the daily milk yield for each lactation. Not surprisingly they found the fit to be extremely good. Other work in 1977 by Schaeffer, Minder, McMillan and Burnside, and by Wiggans and Van Vleck (1979) were aimed at improving milk predicting

Figure 3.1 The Shape of the Lactation Curve



qualities by using nonlinear models. In the latter case, this work involved using the last test day sample and using separate mathematical relationships to describe the three major parts of the lactation curve.

The discussion to this point has centered around constructing more accurate milk predicting models in the face of a highly variable lactation curve. However extensions of a model's ability to predict milk production and serve as an aid in making farm management decisions has also been done. Selection, culling and mating decisions have been based on cows part records being extrapolated to full lactation. Oltenacu and Ainslie (1976), using the milk predicting model of Keown and Van Vleck (1973) and forecasted milk prices, were able to demonstrate that projecting the income from milk sales allowed dairymen to better plan their cash flow. Wiggans and Van Vleck (1978) demonstrated that incorporating the proportion of concentrates fed to dairy cattle into a milk predicting model did not alter the shape of the lactation curve and hence its use in predicting milk for farm management purposes.

The most extensive use of the shape of the lactation curve for use as a farm aid is the Herd Management Control program administered by the British Milk Marketing Board. This program makes use of the vast amount of information held in the computer based National Milk Records and is used as a management aid for consulting officers and dairy farmers. As R. J. Clothier's summary of the program to the Edinburgh Dairy Conference in 1977 stated:

> "By comparing each cow's predicted yield with her recorded yield at each monthly recording it is possible to identify the problem cows, isolate the causes of poor production and plan corrective action. The sum of individual predictions provides a reliable prediction of herd yield.
>
> This herd yield is plotted on a graph. The

graph serves three main functions. Firstly, it acts as a check on herd production from week to week between milk recordings as the farmer is expected to plot weekly yield against predicted yield and to note the relative slopes of the two lines. Secondly, it provides a picture of the years production against predicted production which aids in identifying periods when management could be improved. Thirdly, the graph may serve to monitor changes in management."

The basis for this service has been developed from the work of Wood (1969) and his analysis of the lactation curve. In this program the management service serves not so much as an accurate predictor of milk production but as a management aid in alerting the dairymen of the need to reassess his management practises, feeding schedules and quality, etc. if the graph slopes between actual and predicted milk yield are not the same.

C. Predicting Milk on an Aggregate Basis

Studies in this area have aimed at evaluating industry supply in response to an increase in milk prices since dairying is a highly regulated industry. The hypothesis used was that estimating this response accurately would provide dairy policy makers with the ability to provide for an adequate supply of milk and help maintain a "reasonable" balance between production and consumption. Brandow (1951) used simple single equation regression analysis to estimate milk supply for the United States. Halverson (1955) using the same statistical procedure expanded this work further by estimating milk production per cow as a function of the milk-feed price ratio, hay production, and cow numbers. This work was conducted on each of six regions and in all cases production was found to be highly inelastic. Halvorson (1958) used a Nerlovian distributed lag model to determine the short and long run price elasticities for milk in the United States. He found these to be in the ranges of 0.15 to 0.30 and 0.35 to 0.50 respectively. Ladd and Winter (1961), using single equation regression analysis on time series data, estimated milk supply elasticities as a function of average output per cow and the number of cows in the United States on January 1 of the year of prediction. Other variables were encompassed into the model to properly expand upon the estimation of these two major variables.

Wilson and Thompson (1967) used simultaneous equation models to determine equilibrium price when both supply and demand relationships were considered. Zepp and McAlexander (1969) reported that regression analysis was more appropriate to use than non-flexible price lag structures. Chen, Courtenay and Schmitz (1972) using a polynomial lag formulation and the premise that the quantity of milk produced in a given time period is a function of the price of milk, prices of inputs used in milk production, returns obtainable from competing commodities and the existing technology, measured the lagged output response resulting from a changed product price. They concluded that output response to a given price change increased through time and then declined; that a polynomial lag formulation offered added advantages over that of geometrically declining distributed lag price structures; and that in general the whole area of supply response was fraught with certain estimating and theoretical problems.

To date the use of distributed lag models to predict milk production appears to be a research area open to different interpretations. Firstly, Griliches has stated that most distributed lag models have almost no or only a very weak theoretical underpinning. Thus it is hard to determine which lag models to accept or reject. Secondly, the use of time series data in which more than one price change may have occurred results in measuring the responsiveness of production that is not predicated on a once-and-for all price change. In view of these limitations, measuring milk production response using distributed lag models has generally been viewed as less than a perfect science.

D. Relevance of the Literature to this Study

In attempting to predict milk production in Alberta, both the work done on the shape and characteristics of the lactation curve and the concepts underlying supply response were drawn upon. The development of the four models for this study had to meet two criteria; 1) ease of use for predicting supply and 2) use the Dairy Herd Improvement program as the basis of study. Alberta milk supply was theorized to be a function of the number of cows-in-milk for a given month. This simple functional relationship was expanded upon in the Complex models by segregating dairy herds into common producer categories. The work of the lactation curve was used in the development of the Stage-of-Lactation model to determine if the number of cows-in-milk at a common part of the lactation curve for a particular producer category would improve on the predictability involved as well as serve as a ready "barometer" of cow movements. To the extent that aggregate milk production is only a function of the number of cows-in-milk and that other variables that might suitably be appropriate for measuring supply response are viewed as being stochastic, the overall accuracy of the prediction might be hurt. However the absence of these variables allows for ease of use and may prove to be quite acceptable if accuracy of use is not affected substantially.

IV. METHODS AND PROCEDURE

The main objective of this study was to develop an econometric model suitable for predicting milk production in the Province and to compare them for accuracy and ease of use for the eight month period November, 1978 to June, 1979. Four models were chosen for development to reflect two sample bases and two sampling procedures that were assumed to the study. For ease of use these four models were identified as Complex and Simplified Stage-ofLactation and Complex and Simplified Cows-in-Milk models. The only difference between the complex and simplified designations was with respect to the sample size and the designation of individual producers by type of shipment. The simplified models dispensed with this latter differentiation and were developed from a smaller sample base.

The essential element to predicting milk production for a particular month was to predict average monthly production for a herd on DHI and then extrapolate this average production over all DHI herds that were of the same producer category. To encompass those herds that were in the same category but not a participant of the DHI program, deliveries between DHI and non DHI herds per month would be compared over the 12 month period of July 1978 to June 1979 to obtain a monthly production coefficient. Total production for a particular category would be the sum of the predicted production of DHI herds plus predicted production of non DHI herds. This aggregate production would then be multiplied by a monthly delivery coefficient which represented the proportion of milk produced in a given category that was actually delivered. Summing over all five categories determined total provincial milk delivered for a given month.

To select the production categories seasonal production patterns for different types of producers were observed over the past three years. Although milk producers could be categorized into simply fluid or industrial producers, the cross over between the two markets in the last few years suggested more well defined categories might be advantageous in order to achieve increased accuracy. It was theorized that fluid production, because of its daily quotas, should have an even seasonal pattern of production while industrial producers were theorized to have a curvilinear pattern of production with production peaking in the May-July period and being lowest in the November-December period. The two classes of graduated entrant were theorized to behave somewhere between these two extremes. The Graduated Entrant 1975-77 approximates a fluid producer due to the 800 pounds of daily milk quota earned as a result of being in the plan. In addition, additional fluid quota can be earned if production takes place above quota and more fluid quota is distributed as a result of increased provincial consumption. The Graduated Entrant 1977-79 is locked-in with respect to fluid milk quota and any overproduction enters the industrial milk market. Hence this type of producer was theorized to behave as an industrial producer. Therefore each milk producer could be classified into one of five categories. These were designated as Traditional Fluid, Graduated Entry 1975-1977, Graduated Entry 1978-1979, small Industrial milk (less than 10200 lbs MSQ) and large Industrial milk (greater than 10500 lbs MSQ). To properly identify each producer's category, a computer printout of all dairy producers in Alberta was obtained for June 1979. Each producer was designated into one of eight different categories as well as any participation in the Alberta DHI program. Because not all producers on the DHI program could be properly identified from this information, a cross check of all producers in the DHI Herd Master file was made with the Alberta Dairy Control Board's Market Share Quota List. Cream producers were disregarded for purposes of this study and the two small industrial producer categories were amalgamated into a single category. A sampling of DHI and non DHI herds from each category was done for development of the respective models and for comparison of milk deliveries within category. The number of producers in the Province by category, the number of DHI herds sampled for the study and the number of non DHI herds sampled for calculation of the monthly production coefficients is shown in Table 4.1.

The sample size was determined by calculating the standard deviation of production for each category chosen in the study and selecting a standard error that was acceptable for the study at a .05 significance level. Standard

TABLE 4.1

JUNE 1979 DAIRY PRODUCERS BY CATEGORY

Category	Total in Prov.	Total on DHI	Sampled (DHI)	Sampled (non DHI)
Fluid	636	283	62	30
GE 1975-77	157	73	25	30
GE 1978-79	302	101	26	30
Industrial				
less 6500	210	13	7	15
6500-10500	215	23	8	15
more 10500	188	47	19	30
Cream				
less 500	1099	3	-	-
500-6500	2874	19	-	-
more 6500	48	4	-	-

deviations for each category of producers was calculated from an Alberta Agriculture computer printout for DHI herds in each category. The printout contained data for the period November 1977 to October 1978. Although this printout was incomplete, it did estimate the mean and standard deviation for each category. The mean and standard deviation for each category for the month of October is shown in Table 4.2. The high standard deviations for each category relative to the means suggested a large sample size for each category should be used if the .05 significance level was desired. Hence assuming a normal population, a total allowable standard error of 4000 kgs., a significance level of .05, and the October herd printout of standard deviations the following formula was used to calculate the sample size for each category.

4000 / 1.96 = S.D. / square root of N

where:

4000 = the allowable standard error for each category
1.96 = the confidence interval of 2 standard deviates z
S.D. = the sample standard deviation of each category
N = the number of herds to be sampled

This large sample size was possible for only the fluid milk category since the other four categories had too few herds enrolled on the DHI program to meet the determined sample size. The number of herds calculated for the sample was

TABLE 4.2

DHI OCTOBER PRODUCTION BY CATEGORY

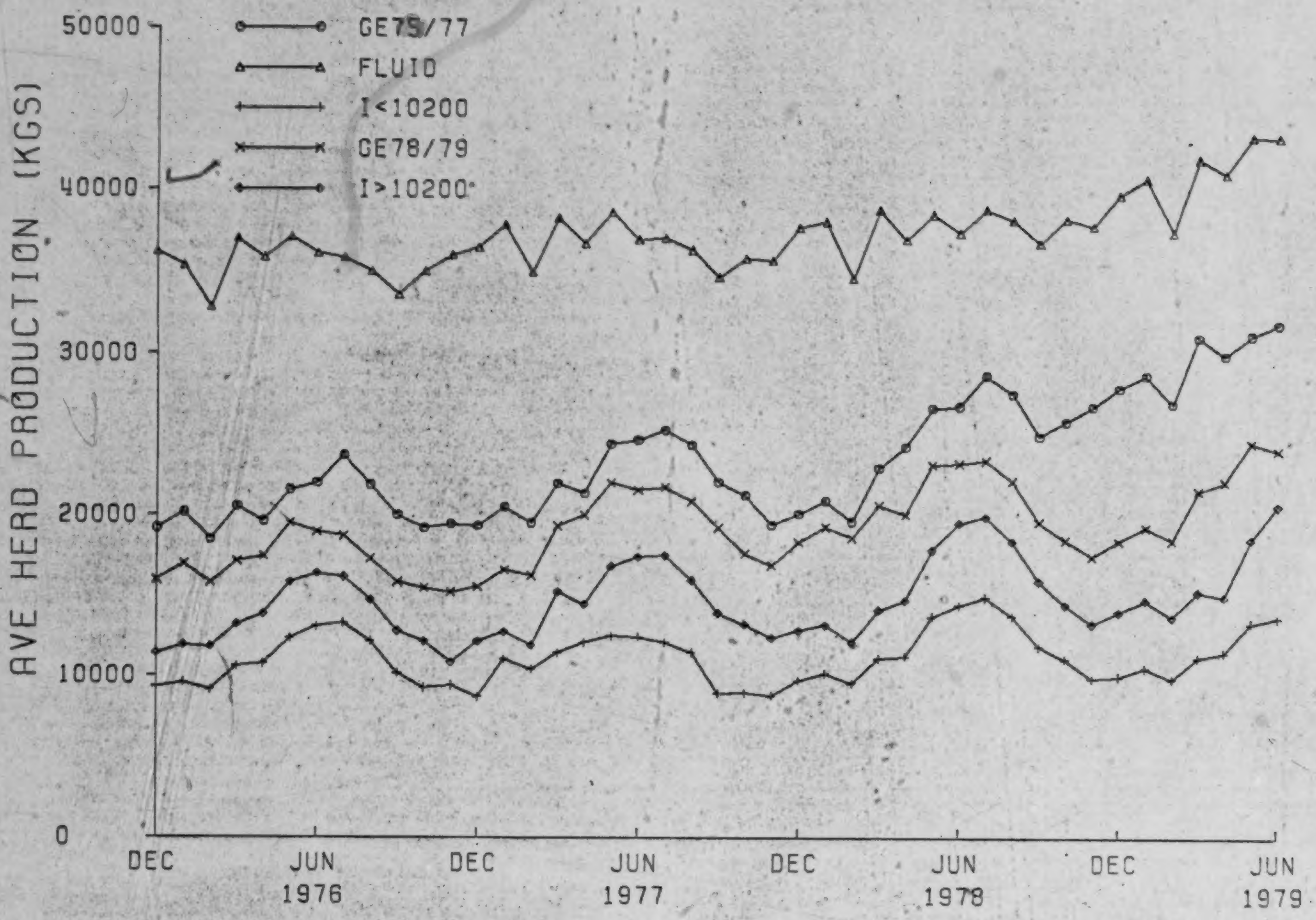
Category	N	Mean	Standard Deviation
Fluid	177	31377	17602
GE 1975-77	76	23121	8888
GE 1978	40	20289	9379
Industrial	107	17155	9030
Cream	29	7491	6449

subject to further change as a result of the inability to cross index DHI herd numbers with the corresponding numbers of the Dairy Control Board printout.

To check the production assumptions regarding the producer classifications chosen as well as assist in the selection of an appropriate model specification to use, average monthly production for the sampled herds in each category was compared. Figure 4.1 shows the results of these comparisons since December 1975.

Since the DHI program is a computer based program, tapes of monthly production data for cows enrolled on the program for the time period November 1978 to June 1979 were obtained. For each month this consisted of herd statistics (a Herd Master file) and individual cow data (a Cow Master file).

Figure 4.1 Average Herd Production Comparisons by Category



To develop models that considered different aspects of cows-in-milk, both the complex and simplified models were developed from each data file. These were respectively called the Cows-in-Milk and Stage-of-Lactation models. It was theorized that the Stage-of-Lactation model with its more extensive breakdown of cows-in-milk into six different lactation stages should be of greater benefit to policy planners. The simplified models were developed from a sampling modification of that used for the previous models. They were developed to see if the increased ease of use was more than offset by the expected reduced accuracy.

A. Testing For An Appropriate Model

It was theorized that a linear model specification should be the most appropriate model to use since the relationship between a herd's production and the aggregate number of cows in the herd should be linear in nature. To test this hypothesis the Stage-of-Lactation model was used with the Traditional Fluid and small Industrial-milk categories (these two categories represented the two production extremes shown in Figure 4.1). Linear, double log, and two semi-log models were tested with November's stages of lactation predicting milk production for each month up to June. Selection of the best model to use was predicated on the coefficient of determination (R^2), and the standard error of the estimate .

B. The Complex Stage-of-Lactation Model

Data for each cow in a particular herd is stored in the DHI Cow Master file. This data includes such information as her age, number of days in milk, days dry, days in calf, etc.[23] This model was developed using the number of days in milk as the important determinant of production for each category. It was theorized that using different stages of lactation should be more descriptive of herd changes and supply the user with more information when actual and predicted yields differed significantly. Drawing upon the literature, the lactation period of 305 days was broken down into 6 different stages (dried off was included as a stage). These were chosen for the following reasons:

0-40 days - this stage would reflect additional calvings immediately

41-80 days - this stage would reflect the peak production of cows

81-150 days- this stage would reflect any falloff after peak production was reached and still at a high level

151-305 days- this stage would reflect on cows declining in production and should be linear in nature

306+ days- this stage will reflect cows falling outside the normal lactation period and having minimal production

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[23] See Appendix 3 for a printout of the complete information available on each cow.

Cows Dry - this stage would be viewed as a "slack" variable and should reflect possible milk production response three or more months into the future

After sampling from each category in accordance with Table 4.1, data from the cow master file for all the sampled herds was separated into each of the six stages listed above. Ordinary least squares (multiple regression) analysis was then used to derive prediction equations for the same month and from one to as many seven months into the future. In its linear form the model for an individual herd in a specified category would appear as follows:

$$Y(j+m) = B0 + B1(m)*X1(j) + B2(m)*X2(j) + B3(m)*X3(j) + B4(m)*X4(j) + B5(m)*X5(j) + B6(m)*X6(j)$$

where:

Y = monthly production in the j+mth month where j refers to the data or base month and m refers to the number of months being predicted into the future

B0 = a constant

B1 = a coefficient associated with the number of cows in milk for the 0-40 day period

X1 = the number of cows-in-milk for the 1 - 40 day period in the jth month

B2 = a coefficient associated with the number of cows in milk for the 41-80 day period

X2 = the number of cows-in-milk for the 41 - 80 day period in the jth month

B3 = a coefficient associated with the number of cows in milk for the 81-150 day period

X3 = the number of cows-in-milk for the 81 - 150 day period in the jth month

B4 = a coefficient associated with the number of cows in milk for the 151-305 day period

X4 = the number of cows-in-milk for the 151 - 305 day period in the jth month

B5 = a coefficient associated with the number of cows in milk for greater than 305 days

X5 = the number of cows-in-milk for the 306+ day period in the jth month

B6 = a coefficient associated with the number of dry cows

X6 = the number of dry cows in the jth month

This process was repeated for each of the 5 categories until five equations were obtained for each month being predicted. Coupled with 8 equations for each category for November, 7 equations for December,etc.,........and 1 for June, a total of 180 equations were obtained for this model over the time period under study.

The equations predicted average production for a DHI herd for a given month. A monthly table was constructed from a comparison of milk deliveries to include those producers outside the DHI program but within the same category. This table was produced by randomly sampling herds outside the DHI program and comparing milk deliveries with those DHI herds used in the model development. This was done by determining the dairy plant to which each sampled producer shipped. Comparing deliveries over a 12 month period and calculating the average monthly shipment for each category allowed determination of a monthly production coefficient.

Therefore the total milk produced for a specific category in the Complex Stage-of-Lactation model could be expressed as follows:

$$Y(j+m) = N*P(j,k) + G*n*P(j,k)$$

where:

Y = the total milk production for the kth category in the j+mth month where j = the base month, $m = 0,1,2,\ldots.7$ and $k = 1\ldots..5$

P = the average predicted production of herds on the DHI program for the kth category and jth month

G = a production coefficient for dairy herds outside the DHI program in the mth month

N = the number of herds in the kth category and jth month enrolled on the DHI program

n = the number of herds in the kth category and jth month not enrolled on the DHI program

The amount of this milk that was actually delivered to plants could be calculated by multiplying total predicted production for each category by an appropriate monthly delivery coefficent. Total predicted deliveries for a future month could be determined by summing this predicted milk delivered over all the categories for a given month.

C. The Complex Cows-in-Milk Model

The only difference between the Stage-of-Lactation model and the Cows-in-Milk model was in the degree of complexity with which the number of cows-in-milk was expressed. The data in the herd master file consisted of each herd's production, number of cows in the herd, and percentage of cows-in-milk by month. Appendix 4 shows the typical information in this file. For this model, monthly production was theorized to be a function of two variables: the number of dry and milking cows in the herd at any given time. In its simple linear form this relationship for a particular herd in a specified category would appear as follows:

$$Y(j+m) = B0 + B1(m)*X1(j) + B2(m)*X2(j)$$

where:

Y = monthly production in the j+mth month where j refers to the data or base month and m refers to the number of months being predicted into the future

$B0$ = a constant

$B1$ = a coefficient associated with the number of cows in milk

$X1$ = the number of cows-in-milk in the jth month and kth category

$B2$ = a coefficient associated with the number of cows in milk in the jth month and kth category

$X2$ = the number of cows in the ith herd in the jth month

The overall Herd Master Model for predicting milk production in the Province could therefore be expressed as follows:

$$Y(j+m) = N*P(j,k) + G*n*P(j,k)$$

where:

Y = the total milk production for the kth category in the j+mth month where j = the base month, m = 0,1, 2,....7 and k = 1,....5

P = the average predicted production of herds on the DHI program for the kth category and jth month

G = a production coefficient for dairy herds outside the DHI program in the mth month

N = the number of herds in the kth category and jth month enrolled on the DHI program

n = the number of herds in the kth category and jth month not enrolled on the DHI program

The amount of this milk that was actually delivered to plants could be calculated by multiplying this total predicted production for each category by an appropriate monthly delivery coefficent. Summing over all categories for a given month allowed total milk deliveries to be predicted.

D. The Simplified Models

To develop these models the breakdown of producers by category was observed for June 1979. These 69 producers were chosen in accordance with the proportion of herds that each category represented for this month. The 69 producers were randomly sampled from the 147 producers that were used in the development of the complex models. The breakdown of producers by category is shown in Table 4.3.

It was theorized that use of these models should guarantee ease of use since only one equation was necessary for predicting as opposed to the five needed with the complex models. Regression equations were calculated for the same time period for both a Stage-of-Lactation and Cows-in-Milk model using the same model specification as in the complex determinations. Milk production using this model was theorized to be as follows:

$$Y(jkm) = N*B(j) + Cows*B(j)$$

where:

Y = the total milk production for the kth category in

TABLE 4.3

SAMPLING OF HERDS BY CATEGORY FOR THE SIMPLIFIED MODELS

Category	Number
Fluid	25
GE 75/77	7
GE 78/79	11
I<10200	14
I>10200	12

the j+mth month where j = the base month and
m = 0,1,2,.....7

P = the average predicted production of herds on the DHI program in the jth month

G = a production coefficient for dairy herds outside the DHI program in the mth month

N = the number of herds in the jth month enrolled on the DHI program

n = the number of herds in the jth month not enrolled on the DHI program

This predicted production was then multipled by a delivery coefficient. For these models this coefficient was a monthly weighted composite of the coefficients determined previously for the complex models.

In total the complex and simplified model specifications resulted in 432 equations being generated.

V. ANALYTICAL RESULTS

A. Introduction

There are three groups of criteria used to judge least squares regression results: theoretical, statistical and predictive. The theoretical criteria were not important to this study since a structural analysis of the coefficients was not made. The statistical criteria were used to check the hypothesis of a linear model specification.

The preceding chapter outlined the analytical procedure used in the development of an appropriate milk predicting model. The choice of the variables used in each model was predicated on 'a priori' reasoning and the need to use the two DHI files as a base. Least squares analysis was used to determine the parameters of each models base. Initially the hypothesis that the number of cows in the herd and total herd production should have a linear relationship was tested. Four different model specifications were tested on the Complex Stage-of-Lactation model using the Traditional Fluid and small Industrial producer(<10200 MSQ) category. These two categories represented the two seasonality extremes associated with milk production. Regression analysis was performed with November's stages of lactation predicting monthly production for each month up to June. Model specifications tested were a linear, double logarithmic, and two semi-log formulations. One semi-log formulation used logged independent variables while the other was log-linear where only the dependent variable was transformed. To facilitate these transformations any variable observations in the study that were 0 were set equal to 1. The following criteria were then used in choosing the appropriate model:

1. the standard error of the estimate[24]
2. The coefficient of multiple determination(R^2)
3. Simplicity in use

Other things being equal, the linear model would be chosen because of its relative ease of use and 'a priori' reasoning.

B. Results on the Choice of Model

The results on the choice of model are presented in Table 5.1 and Table 5.2. Since the F-tests and t-tests were not substantially different among the models tested only criteria (1) and (4) above are reflected in the results. The linear model was chosen over the double log specification mainly on the strength of a lower standard error of estimate, its simplicity and 'a priori' reasoning.

Multiple regression analysis was then performed on the data unique to each DHI file. Complex Stage-of-Lactation and Cows-in-Milk models were developed with monthly independent variables for each herd regressed with monthly production for the months of November 1978 to June 1979.

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[24] a small standard error would suggest a better fit of the regression line with the data and more confidence could then be placed in the results obtained.

TABLE 5.1

STANDARD ERROR AND R² COMPARISON FOR THE FLUID MILK CATEGORY

Month	Yield	Linear	Log-linear	Linear-log	Dble.log
Nov.	37874	6156 (94.8)	8588 (82.3)	10601 (84.8)	6380 (90.4)
Dec.	39755	6974 (94.0)	9054 (82.0)	11523 (84.2)	6727 (90.4)
Jan.	40739	7659 (93.1)	9021 (82.7)	12550 (82.3)	7159 (89.5)
Feb.	37483	6914 (93.3)	11484 (81.8)	11539 (81.8)	7032 (88.1)
March	41973	7720 (93.3)	10470 (79.5)	13114 (80.8)	8882 (85.5)
April	41001	7246 (93.7)	10734 (78.0)	12420 (81.7)	9248 (83.5)
May	43250	6664 (94.6)	10223 (80.7)	12356 (83.0)	9007 (84.7)
June	42227	6488 (94.5)	9346 (82.0)	11679 (83.5)	8388 (85.5)

TABLE 5.2

STANDARD ERROR AND R² COMPARISON FOR THE SMALL INDUSTRIAL MILK CATEGORY

Month	Yield	Linear	Log-linear	Linear-log	Dble.log
Nov.	9833	2028 (90.0)	1626 (82.3)	3017 (77.6)	2062 (74.1)
Dec.	9949	3009 (79.6)	4835 (55.2)	4219 (61.9)	5643 (17.4)
Jan.	10498	3078 (80.4)	4187 (51.8)	4470 (62.5)	5239 (30.0)
Feb.	9809	2653 (79.2)	2965 (53.4)	3911 (64.9)	3532 (50.7)
March	11162	2557 (83.8)	2877 (60.4)	3844 (72.1)	3466 (59.1)
April	11473	2829 (81.0)	3216 (71.1)	3844 (69.8)	3810 (42.3)
May	13305	3843 (75.0)	4267 (67.2)	4898 (65.0)	5185 (41.2)
June	13635	3651 (77.8)	4434 (66.4)	4791 (69.9)	5114 (30.3)

The Stage-of-Lactation model expressed monthly production as a function of the number of cows in 6 different stages. A list of the equations generated for each category for these eight months is presented in Appendix 5. The Cows-in-Milk model expressed the same basic relationships although the five different stages of lactation were grouped into one variable. Cows dry was retained as an explanatory variable. A list of the equations generated for each category for this model is given in Appendix 6.

Two further models were developed on the basis of Stage-of-Lactation and Cows-in-Milk. These two models, referred to as the simplified models, were developed with the idea of determing if milk could be predicted irrespective of category. The equations for these two developed models are listed in Appendix 7 and 8.

Although the Cows-in-Milk model was only a modified Stage-of-Lactation model, the differences between the two with respect to the significance of individual variables and the multiple coefficient of determination suggest one might have inherent advantages. One such advantage was theorized to be that the Stage-of-Lactation model provided more information and therefore offered a stronger "signal" of future milk production.

C. Correlation Analysis

The presence of multicollinearity problems was checked for the four models even though the efficiency of forecasts is unaffected by the correlation between the independent variables. Forecasts depend only upon the total amount of information about the dependent variable contributed by the independent variables and is not dependent upon their effects taken separately[25]. In this study, any problems associated with multicollinearity were anticipated to be with the Stage- of-Lactation models since these models had the greatest number of independent variables. It was theorized that a high degree of association should exist among certain variables as they move through time. This is due to the fact that cows in one stage at time "t" may be in a succeeding stage at time "t+1". For example, cows in the 41-80 day stage all will be in the 81-150 day stage in two months time. To substantiate this, the correlations among these variables were observed. Table 5.3 shows the degree of association among the November, January and April variables in the Simplified Stage-of-Lactation model. The results obtained substantiated this hypothesis. For example, cows in the 0-40 day stage in November have an increasing degree of association with succeeding stages in January until the 151-305 day stage is reached. A levelling off of this association at this stage is expected since November cows

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[25] David A. Aaker *Multivariate Analysis in Marketing: Theory and Applications* Belmont Calif. Wadsworth Publishing Co. 1971

TABLE 5.3

MONTHLY LACTATION STAGE CORRELATION COMPARISONS

Nov. Days	November, January, April Days in Milk																	
in Milk	0-40			41-80			80-150			151-305			306+			Cows Dry		
	Nov	Jan	Apr	Nov	Jan	Apr	Nov	Jan	Apr	Nov	Jan	Apr	Nov	Jan	Apr	Nov	Jan	Apr
0-40	-	.74	.60	.77	.88	.65	.55	.87	.79	.57	.63	.84	.43	.31	.15	.68	.26	.22
41-80	.77	.72	.60	-	.70	.60	.60	.94	.72	.55	.61	.86	.35	.30	.08	.65	.20	.19
81-150	.55	.69	.53	.60	.56	.54	-	.66	.61	.47	.77	.82	.24	.09	.03	.43	.22	.22
151-305	.57	.66	.64	.55	.55	.59	.47	.57	.73	-	.84	.56	.39	.55	.44	.59	.47	.51
306+	.43	.32	.43	.35	.39	.43	.24	.40	.41	.39	.45	.46	-	.64	.47	.27	.05	.02
Cows Dry	.68	.81	.50	.65	.73	.68	.43	.67	.80	.59	.58	.65	.27	.35	.06	-	.25	.23

will not have reached this stage in 60 days time. The 151-305 day stage in April reveals a high correlation with November's 0-40 day stage. The November cows-dry stage also appears to have a high degree of association with January's 0-40 day stage and less over time with January's other stages. On the other hand, the degree of association of November's cows-dry stage with April's stages indicates an increase until the 81-150 day stage is reached and a decreasing relationship thereon. Both of these relationships substantiate the initial hypothesis that any month's dry cows could be viewed as a "slack" variable pointing to future milk production. Any November cows that were dry and freshened in December or January would be reflected in January's first stage and April's third stage.

D. Coefficient Tests of Significance Analysis

To test the theory that the 'cows dry' variable could be viewed as a 'slack' variable in predicting future months milk deliveries the coefficients and their level of significance was observed. As expected the level of significance for this variable increased through time. This can be interpreted as the variable becoming more important when predicting milk delivery several months into the future. All the models exhibited this significance. In all cases the variable associated with the number of cows-in-milk was significant at the .01 level. For the Stage-of-Lactation models this significance was pronounced with the first four variables. Cows that remained in milk after completing the normal 305 day lactation generally were not significant at the .10 level. In this respect the latter models supplied information that was not possible with the Cows-in-Milk models.

E. Other Results

The original development of the Stage-of-Lactation and Cows-in-Milk models was done on DHI data. To properly ascertain the amount of "bias" or difference between these two groups, milk deliveries for the two groups were compared. The time period considered for this part of the study was July 1978 to June 1979. This table allowed the developed models to be used to predict milk production for herds on DHI and then using this predicted amount, extrapolate over herds in the same category but not on the DHI program. The coefficients derived from this study are shown in Table 5.5.

Aggregating this production over categories allowed total production in Alberta to be predicted. Since final results were expressed as milk delivered to individual plants, these production figures had to be adjusted downward.

A random sample of eight producers from each category was made and milk production and milk deliveries for the same 12 month period was compared. Results are expressed in Table 5.6. The average predicted production per herd in each

TABLE 5.5

NON DHI PRODUCTION AS A PERCENTAGE OF DHI PRODUCTION

Base	Producer Category				
Month	Fluid	GE75-77	GE78-79	1<10200	1>10200
January	.651	.775	1.109	.856	1.010
February	.656	.759	1.126	.846	1.026
March	.666	.769	1.137	.901	1.023
April	.661	.793	1.111	1.001	1.087
May	.695	.829	.966	1.005	1.029
June	.688	.820	.967	1.028	.944
July	.671	.926	.971	.924	.955
August	.655	.937	.975	.909	.955
September	.665	.887	1.062	.988	.979
October	.695	.845	1.068	.924	.988
November	.676	.748	.987	.939	1.008
December	.655	.779	.924	.824	.973

TABLE 5.6

DELIVERIES OF MILK AS A PERCENTAGE OF PRODUCTION

Predicted Month	Fluid	Producer Category GE76/77	GE78/79	I<10200	I>10200
January	.936	.931	.938	.927	.815
February	.924	.917	.927	.923	.825
March	.952	.944	.932	.953	.839
April	.949	.927	.952	.957	.837
May	.961	.941	.947	.920	.849
June	.968	.971	.969	.904	.809
July	.968	.960	.914	.966	.848
August	.969	.965	.927	.993	.827
September	.942	.944	.926	.921	.820
October	.959	.926	.935	.983	.808
November	.945	.954	.902	.913	.771
December	.948	.971	.939	.951	.810

category for the Complex Stage-of-Lactation and Cows-in-Milk models is shown in Table 5.7.

The total number of herds for each category and the proportion of these herds that was also enrolled on the DHI program was determined. The difference between total herds in a category and the number of herds on DHI for the same category allowed calculation of the number of herds within category and not on the DHI program. Using herd identification numbers from the DHI program and cross referencing these numbers with their Milk Board registration number allowed separation of herds into the appropriate categories. Using the Summary of Milk Producers information for May 1978, May 1979 and June 1979, the number of herds for each category was estimated. To determine the number of producers both on and not on the DHI program for use in the simplified models, a summation of herds for each of the 5 categories was made. Table 5.8 summarizes these findings.

F. Predicting Milk Deliveries using the Complex Models

The actual amount of milk delivered for each month over the years 1974 to 1979 (Figure 5.1) was obtained from the Alberta Dairy Control Board monthly milk and cream production data. Using the average predicted production per head for each category, milk deliveries were predicted over the same time period, November 1978 to June 1979, used in the development of the models. Prediction time periods ranged from the present month to as many as 7 months into

TABLE 5.7

AVERAGE MONTHLY PREDICTED PRODUCTION BY CATEGORY

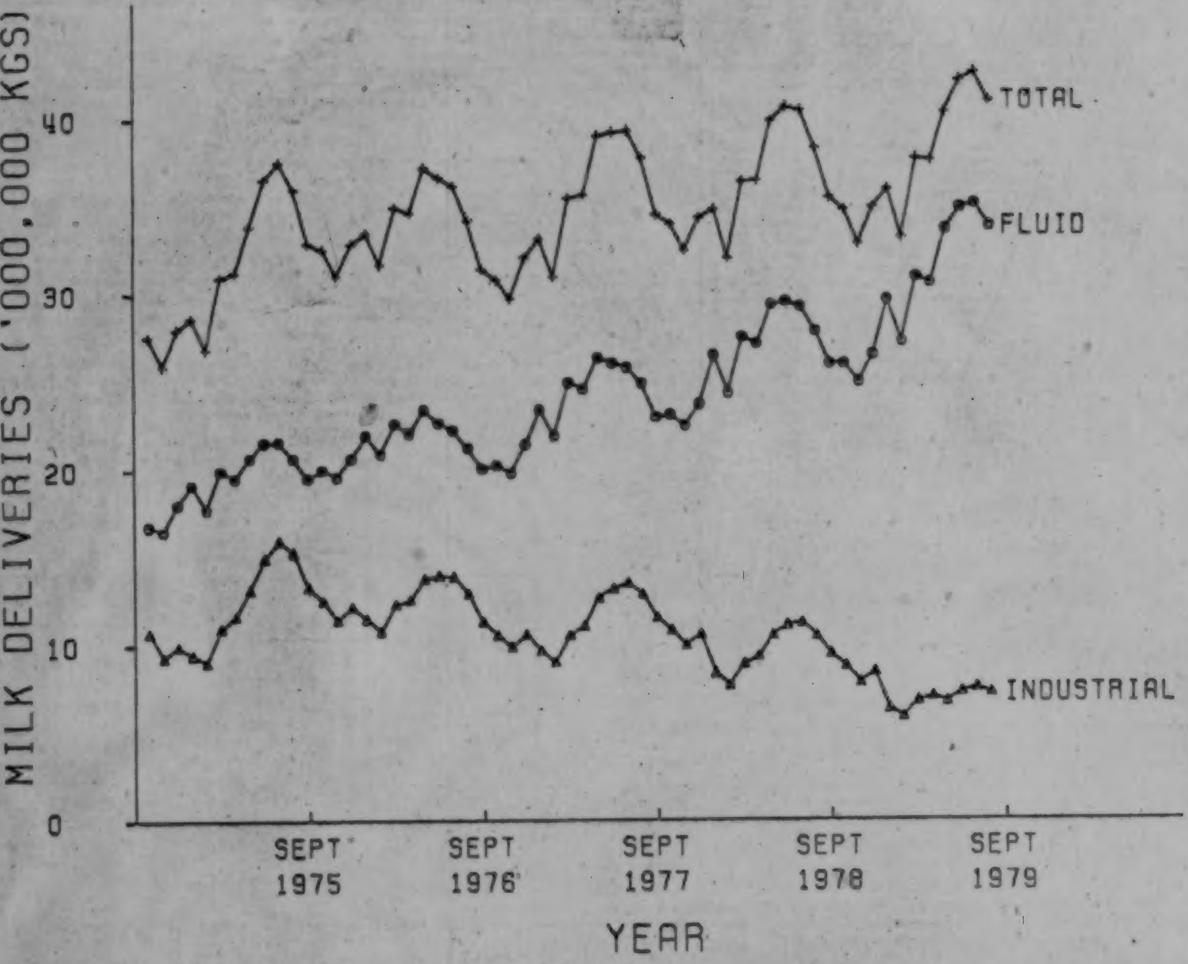
Predicted	Producer Category				
Month	Fluid	GE75/77	GE78/79	I<10200	I>10200
November	37874	26365	17445	9833	13249
December	39755	27546	18392	9949	13991
January	40739	28397	19226	10498	14720
February	37483	26643	18451	9809	13677
March	41973	30662	21521	11162	15253
April	41000	29535	22074	11473	14965
May	43250	31249	24483	13305	18514
June	42227	31817	24333	13635	20570

TABLE 5.8

DAIRY HERDS IN ALBERTA BY CATEGORY AND DHI PARTICIPATION

Month Studied	Producer Category Fluid		QE75/77		QE76/78		Q<10000		Q>10000	
	DHI	NON-DHI	DHI	NON-DHI	DHI	NON-DHI	DHI	NON-DHI	DHI	NON-DHI
November	274	371	74	111	96	46	38	445	47	276
December	278	365	75	110	92	42	39	444	49	274
January	283	363	75	96	96	172	38	322	45	162
February	288	352	75	96	96	173	37	334	45	166
March	287	350	74	97	98	158	36	333	47	151
April	287	353	74	97	98	173	35	333	47	163
May	287	350	73	96	102	208	35	310	47	125
June	283	357	73	96	101	208	35	310	47	125

Figure 5.1 Milk Deliveries by Month



the future. Table 5.10 indicates the percent error associated with each predicted period. With a few exceptions predicted production was low. Estimated milk deliveries displayed the greatest deviation from actual deliveries when present month forecasts were made but tended to be more reliable when future deliveries were predicted. In large part estimates tended to vary the most when November and December time periods were used as the base for prediction. This was due to a large number of herds who were in the Industrial milk category these two months moving into the GE78/79 category in January. This movement influenced future predicted deliveries since these herds were now representative of a category with a higher average production per herd. The predicted deliveries over the 7 months were determined to have an average 2.0% error. On a per cow basis this amounted to an error in estimation of 2160 cows-in-milk if each cow averaged 4091 kgs. per year. An example of the calculations involved in predicting March's milk deliveries using November as the base month is shown below. The general November equation for predicting milk for a category was as follows:

$$Y = D*N*P + D*n*G*P$$

where:

TABLE 5.10

PERCENT ERROR PER TIME PERIOD USING THE COMPLEX MODELS

Base	Predicted Month						
Month	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Nov	-1.49	-3.94	-3.65	-3.48	-2.78	-0.83	-0.56	-2.92
Dec		-3.99	-4.16	0.93	-.056	-2.61	0.50	-2.99
Jan			-4.17	-4.26	-0.63	-.036	-0.90	-2.98
Feb				-4.27	-1.37	-0.46	1.25	-4.34
Mar					-1.37	-0.84	1.20	-2.24
Apr						-0.84	2.28	-2.32
May							2.29	-0.85
Jun								-0.86

Y = the total milk delivered for March

D = the delivery coefficient for a given category for March

N = the number of herds enrolled on the DHI program for a given category in November

P = the average predicted production for a herd in a given category for March

n = the number of herds not enrolled on the DHI program for a given category in November

G = the production coefficient for dairy herds outside the DHI program in March

Therefore the predicted deliveries for March for each category was as follows:

Fluid category:

$$(.952)(274)(41973) + (.952)(.666)(371)(41973)$$

$$= 20{,}821{,}709 \text{ kgs.}$$

GE 75/77 category:

$$(.944)(74)(30662) + (.944)(.769)(111)(30662)$$

$$= 4{,}612{,}635 \text{ kgs.}$$

GE 78/79 category:

$$(.932)(89)(21521) + (.932)(1.137)(46)(21521)$$

$$= 2{,}834{,}175$$

I <10200 MSQ category:

(.953)(38)(11162) + (.953)(.901)(445)(11162)

= 4,669,227

I >10200 MSQ category:

(.839)(47)(15253) + (.839)(1.023)(276)(15253)

= 4,214,754

Summing over all the categories the total predicted production for March was therefore 37,152,500 kgs. The actual milk delivered for this month was 37,667,818 kgs. The percent error associated with the prediction was therefore 1.37% low.

G. Predicting Milk Deliveries using the Simplified Models

These two models were based on an aggregation of certain data components used in the complex models. These aggregations are shown in Table 5.9. Appendix 9 details the calculations involved in determining the two composite production and delivery coefficients. Using the average herd production, a composite production coefficient of .865 to compensate for herds not on DHI and a composite delivery coefficient of .933 to reflect the actual amount of milk

TABLE 5.9

AGGREGATED HERD DATA FOR THE SIMPLIFIED MODELS

Predicted Month	Avg Herd Production	Total Herds	Herds on DHI	Herds not on DHI
November	22452	1771	522	1249
December	23538	1769	533	1236
January	24309	1664	541	1123
February	22422	1665	544	1121
March	25087	1647	543	1104
April	24413	1652	543	1109
May	26390	1636	545	1091
June	26751	1639	540	1099

delivered, deliveries of milk over the same time period used in developing the models was done. The percent error associated with each predicted period is shown in Table 5.11. Predicted production for these models tended to be both above and below the actual amount 75% of the time. The average error of estimate was 5.5%, a greater variation than that obtained in the Complex models. An example of the calculations involved in predicting March's deliveries using November as the base month was as follows:

$$Y = D*N*P + D*n*G*P$$

where:

Y = the total milk delivered for March

D = the composite delivery coefficient of all herds in March

N = the number of herds enrolled on the DHI program in November

P = the average predicted production for a herd in March

n = the number of herds not enrolled on the DHI program in November

G = the composite production coefficient for a herd outside the DHI program in March

TABLE 5.11

PERCENT ERROR PER TIME PERIOD USING THE SIMPLIFIED MODELS

Base	Predicted Month							
Month	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Nov	2.50	0.98	-4.44	-4.29	-6.92	-8.88	-9.05	-11.63
Dec		1.00	1.20	-4.40	-5.91	-5.40	-8.20	-11.70
Jan			1.20	1.30	-6.00	-8.20	-8.50	-10.90
Feb				1.30	-0.40	-8.27	-7.50	-11.20
Mar					-0.40	-2.82	-7.60	-10.30
Apr						-2.80	-2.10	-5.00
May							-2.10	-5.00
Jun								-5.00

Therefore we have:

$$(.933)(522)(25087) + (.933)(.865)(1249)(25087)$$

$$= 40,199,032 \text{ kgs.}$$

The actual amount of milk delivered in March was 37,667,818 kgs. Thus the predicted value was 6.72% high.

VI. Summary, Conclusions, and Implications

A. Summary

This study focused on two aspects of predicting milk deliveries in Alberta. Firstly, it attempted to ascertain the feasibility of developing confident milk predicting models using the DHI program as a base and secondly, if so, which method of approach is was most appropriate for obtaining accurate results. The period of study was November 1978 to June 1979 and four models were tested. Two of these models were grouped and called complex models and were fitted to monthly production data of the Dairy Herd Improvement program by using ordinary least squares (OLS) techniques. A linear formulation was used in developing the models.

Another two models, referred to as simplified models, differed from the former models with respect to herd producer designation. The complex models consisted of herds separated into five producer categories on the basis of past production trends and assumptions about future production. The simplified models consisted of a random sampling of herds irrespective of category. Each of these model groupings were differentiated into two types of models on the basis of the data used in the study. One specification was developed solely from monthly cow data with cows separated into 5 stages of milk as well as cows dry. The other specification used monthly herd data with the number of cows-in-milk and number of cows-dry as the only independent variables.

To properly account for those herds outside of the Dairy Herd Improvement program and in the same producer category, deliveries between a randomly sampled number of herds both on and not on the program was made. A further comparison of the amount of milk delivered relative to the amount produced was made for each category from a random sampling of eight producers on the DHI program.

B. Conclusions

> "Its easy to predict the future.
> The hard part is being right."[26]

The data examined and analyzed, while subject to certain limitations of accuracy, consistency, and reliability does enable some conclusions to be drawn:

1. It is possible to predict milk production and milk deliveries in Alberta using least squares technique and data from the Dairy Herd Improvement program as a base. The so-designated complex models were able to predict production over the same period of time used in the development of the models with an average error of only 2%. Using the simplified model versions predicted

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[26] Harry Browne, New Profits from the Monetary Crisis, New York: St Martens Press 1979 p42

deliveries had an error of 5.5%. Both model specifications were able to predict in the face of an overall increasing trend in milk deliveries and a significant delivery falloff in the month of February.

2. The significance that the cows-dry coefficient achieves in predicting milk deliveries into the future substantiates the hypothesis that the number of cows-dry in the base month can be viewed as a slack variable. That is, these cows eventually freshen and take on an importance in future milk production.

3. Considering the above conclusions, it is suggested that the Complex Cows-in-Milk model be used to develop the study further. This model simplifies the Stage-of-Lactation model into just two variables, cows-in-milk and cows-dry. Data needed for testing of the Stage-of-Lactation models is not currently available and a further 18 month period would be needed to fully develop and confidently test these models. The Stage-of-Lactation model does provide a much stronger signal of a farm manager's herd intentions since milking cows enter more specific stages than just a broad stage of cows-in-milk. For DHI inter-herd movement this is important since milking cows that enter the herd from the purchase of another DHI herd would enter the herd by being placed in those stages of the lactation curve that correspond to the number of days in milk for each new cow. If a preponderance of these cows were to fall into

one stage their effect might more readily explain future deliveries. The Cows-in-Milk model does not take this information into account.

On the other hand herd enlargement through herd purchases probably takes place among herds not enrolled on the DHI program. Accurate days-in-milk for each cow is not available and the simple designation of whether each cow is dry or in-milk is the maximum information available. This is particularly true when small industrial producers and cream producers are involved since so few of them participate on the DHI program. The dynamic nature of this segment of the dairy industry is due to many such producers upgrading or expanding their operations to meet graduated entrant requirements, expanding to become larger industrial milk shippers or being sold to other dairy producers who are expanding. Because this latter movement would be the most prevalent, the Complex Cows-in-Milk model is preferred. The simple information of cows-in-milk and cows-dry meets the needs of the Cows-in-Milk model unlike the Stage-of-Lactation model. In addition, the Complex version with its producer categories is preferred to the Simplified version since it produced more accurate results.

4. Increased accuracy and confidence in the model is obtained if producers are initially partitioned into specific producer categories. The main advantage is that

the standard error of the estimate is much less when producers are initially categorized.

5. A breakdown of the herds presently enrolled on the DHI program suggests that in the last year new enrolments on the program have mainly come from the cream category. It appears that those milk producers interested in the program are already participants of it.

C. Limitations of the Study

Although predictive accuracy was better than first expected considering the large variability among producing herds, certain limitations to the study preclude definitive conclusions being drawn. Firstly, the degree of accuracy possessed by the models was compared over the same time period used in the development of the models. This should result in more accurate results than those expected if the models were tested outside of this time period. Secondly, the models were developed and compared over the relatively short time period of eight months. This was made necessary since data for development of the Stage-of-Lactation models could only be collected on an "as is" monthly basis and would have required 18 months lead time if models encompassing a six month future time period were desired.

Thirdly, the volatility of the industry as it rapidly changes in response to a more open graduated entrant policy makes it difficult to segment herds into appropriate producer categories. This aspect could be the major reason for the models tending to predict low. The simplified models overcome this problem to some extent since only the total number of herds producing in the base month is needed rather than the requirement that the movement of herds among cream, industrial and GE 78/79 categories be clearly monitored. A monthly determination of the number of producers by category would be necessary for model reliability.

Fourthly, the amount of milk delivered as a proportion of herd production (Table 5.7) raised questions of the validity of some of the data. In many instances, herd production for a selected month was less than the milk delivered by that herd for the same month. If this had occurred on an occasional basis, it could be explained as herd expansion through purchases not being reflected in the DHI production data but being felt in the amount of deliveries. However the large number of occurrences suggest either a fundamental error is present in the manner in which some milk figures are determined or producers are not reporting all the cows in their herd. Since deliveries form the basis of payment to producers and deliveries occur approximately every 3 days for a producer, the delivery figures would appear to be accurate.

Lastly, although the industrial sector is producing less of the total production in the province, the absence of many DHI herds in the industrial sector placed limitations on the sampling involved in developing the models. This resulted in an inability to compare DHI deliveries with non

DHI herds for the same producer category.

D. Directions For Future Research

Two major areas provide possibilities for future study. Firstly, now that milk deliveries have been predicted based on estimating average production per herd, accurately determining the number of dairy cows in the Province would prove useful. Currently these numbers are obtained from Statistics Canada studies and are updated every five years. This work could prove beneficial if the number of cows in milk and the number of dairy heifers in the province also formed a part of the study. In both these areas the work itself would supply valuable information as to the direction of the industry (expansion or contraction).

A second area of possible study would be an attempt to explain the difference in monthly milk deliveries by the larger industrial milk producers (Table 5.6). Deliveries as a percentage of production for these producers differ substantially from those of the other producers. Barring sample error, the differences here may reflect management considerations not characteristic of the other producer categories. An in depth study of sampled producers from each of the five categories would test this hypothesis.

Insofar as this particular study is concerned it would serve a useful purpose if it was completed so that monthly usage was possible. In main, this completion is enhanced due to the simplicity with which the four milk predictive models were developed. It was assumed that milk production could be predicted by simply using the number of cows-in-milk as the only important variable. In a larger supply response study, and over a longer time period, this variable would be coupled with other explanatory variables chosen on an 'a priori' basis. Considering the Complex models predict easily over the short term and appear to possess a high potential for accuracy, it is doubtful if the benefits associated with adding variables to improve the accuracy would not be more than offset by the increased costs involved in collecting further formation on a monthly basis so that the model could be used regularly.

The ease with which this program can form an integral part of the information system of Alberta Agriculture can be readily seen. Computer capability exists as a result of the DHI program and the monthly routine of obtaining reliable future delivery totals is quite simple once the sampled herds, equations and pertinent tables form part of the system. In the interests of ease of use base month predictions should probably be limited to four, eight, and twelve month time periods rather than the monthly ones involved in this study. To allow further development of these models a listing of all the herds that participated in the study is given in Appendix 10.

In large part the development of milk predictive models such as outlined in this study allows for the accurate assessment of the dairy industries response to factors that influence decisions at the farm level. In light of the fact that no procedure is in place to monitor these changes, the use of a milk predicting model has validity and the completion of this work has much merit.

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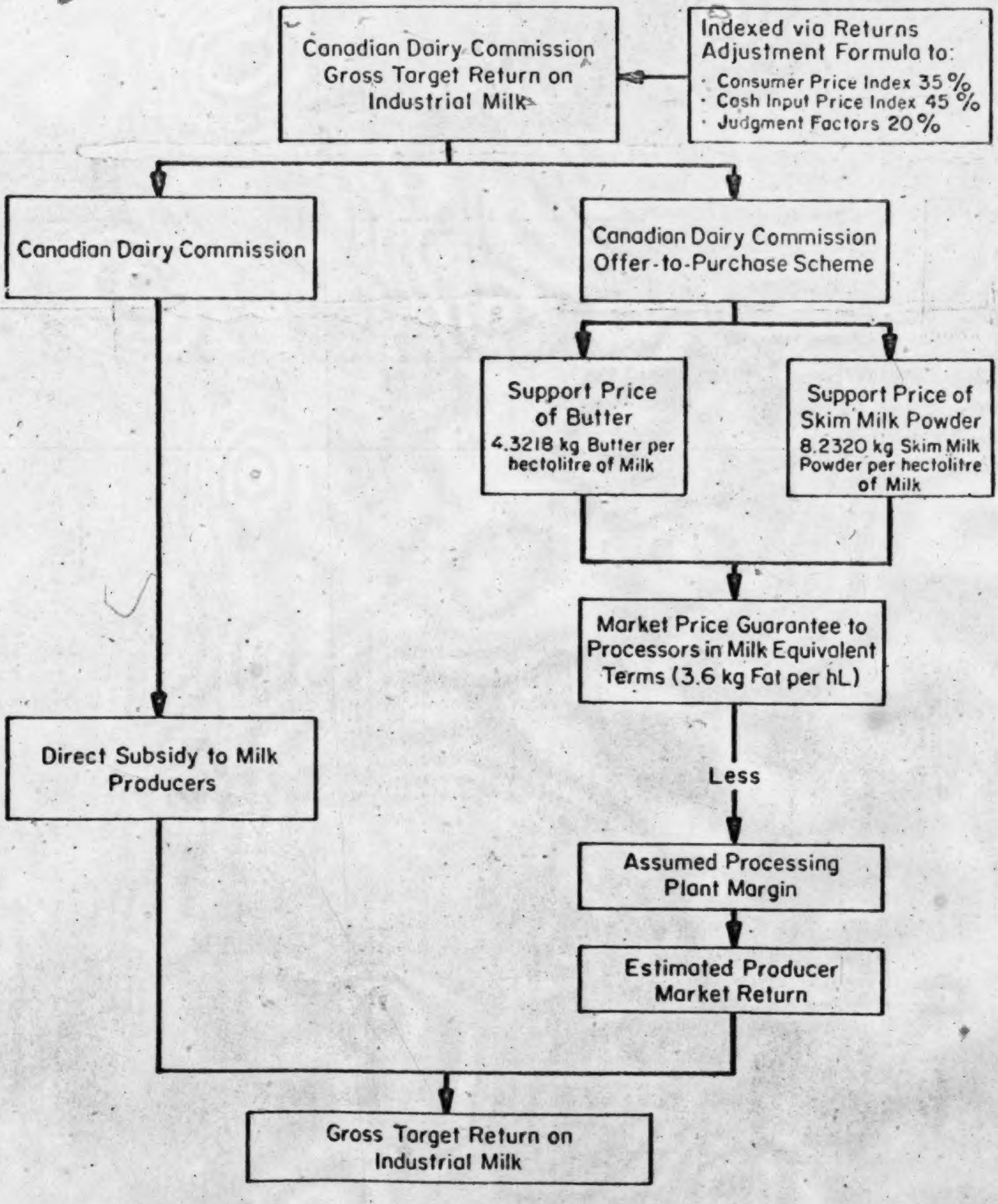
VIII. APPENDIX 1

UNIT RETURNS-SETTING MECHANISM FOR INDUSTRIAL MILK


Canadian Dairy Commission Gross Target Return on Industrial Milk
Indexed via Returns Adjustment Formula to:
· Consumer Price Index 35 %
· Cash Input Price Index 45 %
· Judgment Factors 20 %
Canadian Dairy Commission
Canadian Dairy Commission Offer-to-Purchase Scheme
Support Price of Butter
4.3218 kg Butter per hectolitre of Milk
Support Price of Skim Milk Powder
8.2320 kg Skim Milk Powder per hectolitre of Milk
Market Price Guarantee to Processors in Milk Equivalent Terms (3.6 kg Fat per hL)
Less
Direct Subsidy to Milk Producers
Assumed Processing Plant Margin
Estimated Producer Market Return
Gross Target Return on Industrial Milk

IX. APPENDIX 2

Alberta Dairy Development Program Expanded[27]

The recently announced change to the Alberta Dairy Development Program is intended to provide cream producers and industrial milk producers with an opportunity to change to fluid milk production and to provide fluid milk producers with an opportunity to expand their dairy enterprise. It is also intended to help anyone interested in having a dairy enterprise, to get started.

Assistance under this program is given in the form of interest rebates on loans obtained from lending agencies that have a guarantee agreement with the Alberta Agricultural Development Corporation and which come under the corporation's Farm Development Loan Program. The amount of the interest rebate is $70 per $1000 borrowed for a period of three years.

The change in the program involves the maximum loan that will qualify for the interest rebate. In the case of an individual, it is now $30,000 instead of $12,000. In the case of a partnership or corporation it is now $50,000 instead of $18,000 for two people and $24,000 for more than two people. Under the present program, a partnership or corporation must consist of more than one farmer or farm family to qualify for an interest rebate.

An applicant who received an interest rebate on a loan of $12,000 in the past would be eligible for an interest rebate on the difference between $12,000 and $30,000. Similarly, a partnership or corporation that received an interest rebate in the past on a loan of $18,000 or $24,000 would be eligible for an interest rebate on the difference between either of these figures and $50,000.

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[27] Alberta Agriculture Dairy Herd Improvement News Wetaskiwin April 1979 p9-10

The rebate can be claimed after a complete annual installment of principal and interest has been paid by the borrower. If however, the borrower is in debt to the corporation either directly or through guaranteed advance loans being in arrears, it may apply proceeds from the rebate against the debt.

Following are examples of the types of projects that would qualify for an interest rebate.

1. The construction, alteration, reparation or extension of a building for dairying purposes on a farm already owned or being purchased.
2. Permanent improvements required by the dairy enterprise.
3. The purchase of dairy equipment includes equipment used in final processing, handling and storage of feed. Examples include: forage wagons for "0" grazing, silos, forage conveying systems in and to dairy production facilities, mixer mills and grain rollers.
4. Items directly relating to manure handling systems including: manure spreaders, pumps and even small tractors with blades or loaders to be used exclusively in manure handling.

5. Hay storage sheds and facilities for raising replacement cattle and caring for dry dairy cows.
6. The purchase of milk quota.
7. Other purposes related to a dairy operation that have the approval of the Alberta Agricultural Development Corporation.

X. APPENDIX 3

INSTRUCTIONS TO THE DAIRY HERD IMPROVEMENT PROGRAM USER

1. To ensure a meaningful herd report, the user has an obligation to provide all data as required to maintain complete records for his herd.

THE REPORTS ISSUED BY THE D.H.I. PROGRAM CAN ONLY REFLECT THE ACCURACY OF THE ORIGINAL RECORDINGS. Computer programs will check the incoming entries to see if they are acceptable. If not, the remarks column on the herd report will signal the unacceptable recording. Incorrect entries are not directly altered during computer processing. The herd owner must submit the corrections to maintain error-free records.

2. HOW TO MAKE CHANGES

If any changes are necessary they may be made on the BARN SHEET by striking out the incorrect information and writing in the correction immediately below. An explanation of the change may be made in the "REMARKS" column.

3. IMPORTANT NOTICE!

Since the cow inventory (index) numbers are the computer's only means of identifying the individual cows in your herd, their numbers must not be changed without prior consultation with, and the approval of, the Dairy Herd Improvement Data Control Co-ordinator.

EXPLANATION OF HERD REPORT

4. **HERD I.D.** - A unique identification used to identify the herd to the system. The first two digits indicate the year of enrollment of the herd on the D.H.I. Program.
5. **REGION & DISTRICT** - A code used to identify the D.A. district in which the herd is located.
6. **OWNER** - Name and address to which the herd report will be mailed.
7. **TEST DATE** - Day on which the sampling and recording was completed.
8. **MAILING DATE** - Date the computer processed the herd.
9. **TESTING PLAN** - Owner-sampler or Supervised. Information provided on both programs is identical. The supervised testing plan provides an authenticated record of production.
10. **BATCH** - For Data Control use only.
11. **REG.** - Indicates if 50%, or more, of the herd is registered.

COW IDENTIFICATION

12. **BREED** - refer to "BREED CODES" on reverse side of this page. A registered cow is indicated by a '1' preceding the breed code.
13. **REGISTRATION OR NIP OR EARTAG NUMBER** - All registered animals of each breed are permanently identified by this number as shown on their registration certificates. Grades must be identified by NIP or eartag numbers.
14. **BIRTHDATE** - Although the cow's birthdate is kept on record, only the month and year of birth are printed.
15. **LAST CALVING DATE** - The date on which the cow began her current lactation.
16. **LAST REPORTED BREEDING DATE** - The most recent breeding date reported for the cow.

TEST DAY INFORMATION

17. **STATUS** - refer to "ENTRY STATUS CODES" on reverse side of this page.
18. **MILK** - The total of the P.M. and A.M. milk weights reported on the barn sheet on the test day.
19. **% FAT** - The actual butterfat test recorded on the barn sheet for the test day.
20. **GRAIN FED** - The amount of grain mixture or concentrates fed to each cow on test day as recorded on the barn sheet.

COW MANAGEMENT MEMOS

21. **RECOMMENDED GRAIN DAILY**

The daily grain recommendation is based on the voluntary intake of forage and the qualities of the forage and the grain fed. The following factors are taken into consideration in the calculation of the daily grain requirements on an individual cow basis:

- bodyweight
- age
- stage of pregnancy
- milk production on last test day
- average fat test during current lactation
- voluntary intake of forage
- quality of grain fed

The daily grain recommendation is the calculated amount of grain required to meet the cow's individual needs based on information reported on the barn sheet. It can only be as accurate as the reporting and may have to be adjusted by the dairyman after careful observation of his cows. The minimum recommendation is 2 kg.

22. COW MANAGEMENT MEMOS

Status Code	Change Required	
DB	due to breed	A predicted date, 60 days beyond the last calving date is printed for all cows in milk between 36 and 74 days
OPEN	cows not bred	The word OPEN is printed for all cows in milk more than 74 days and not reported bred
PC	pregnancy check	All cows in calf between 27 and 70 days will have a pregnancy check date printed which is 42 days beyond the breeding date
DD	due to dry	For all cows milking and in calf between 170 and 210 days, a due to dry date will be printed that is 222 days beyond the breeding date
LF	lead feeding	For all cows in calf between 211 and 229 days, a lead feeding date, 264 days beyond the breeding date will be printed
DC	due to calf	278 days beyond the breeding date for all cows in calf between 230 and 275 days. (Average gestation period for Holsteins).

23. COW INVENTORY NUMBER - The number assigned to the cow for computer identification.

24. BARN-NAME OR NUMBER - The name or number used by the owner to identify each cow. Up to 7 letters or numbers (including spaces) are allowed.

25. LACTATION NUMBER - The actual lactation number (or number of calvings) of each cow, regardless of whether the animal was previously on test or not.

26. BODY WEIGHT (TENTHS) - The weight of each cow expressed in units of 10 is estimated from the heart girth measurement the first month on test and re-estimated the first test after each calving.

CURRENT LACTATION

27. Current lactation indicates the number of days a cow has been IN MILK, DRY, or IN CALF since the most recent calving date, as well as the amount of milk and fat produced since that date.

For cows that are considered "Record Commence" the production totals will include only the production accumulated from the date they are entered on test. Predicted production cannot be made for these animals.

28. BREED CLASS AVERAGES

B.C.A.'s are indexes of the cow's production expressed as percentages of the 305 day Breed Class Standard, for all cows of the breed calving at the same age. For a cow that has been in milk for more than 45 days and less than 305 days, estimated B.C.A.'s based on current lactation totals are given. This estimate assumes that the cow will be in milk for a full 305 day lactation. The deviation from herd average is the difference between the cow's B.C.A. milk and fat index and the Rolling Herd Average B.C.A. milk and fat index of all cows completing lactations in the herd within the last 12 months.

Breed Class Averages are an evaluation of the production ability of a cow adjusted for age and month of calving. B.C.A.'s enable the dairyman to compare each cow's performance against the performance of all cows in all herds.

The deviation from the Herd Average allows the dairyman to make a comparison of a cow's performance with that of other cows milking in the same herd, under the same conditions.

B.C.A. values provide a reliable means, through this deviation from the herd average, to be used in culling low producers from the herd. Herd replacements should be kept from superior cows.

PRODUCTION AVERAGES

29. Production averages are expressed for two different time periods:

- Herd average for the most recent test
- Herd average for the past twelve months

These figures are beneficial to the herd owner to assess where his herd ranks in relation to other herds. Production Averages, % Days in Milk and Calving Interval can be used to detect problems in genetic ability, in feeding and in other herd management practices.

The daily average production of milk per cow this month is calculated on the basis of the number of cow days in milk.

AVERAGE NUMBER OF COWS is the average number of cows in the herd (both milking and dry) for the report period after adjustment for part-time cows entering and leaving the herd. It is computed by dividing the number of cow days on test this month by the days in the report period.

% DAYS IN MILK is the number of cows in milk during the report period expressed as a percentage of the average number of cows (previous column). Number of cows in milk is adjusted for part-time cows calving, going dry or leaving the herd during the period.

INSTRUCTIONS TO ASSIST YOU IN COMPLETING THE BARN SHEET

CURRENT TEST INFORMATION

This area should be completed for each cow in milk.

30. SAMPLE No. - The bottle containing the milk sample taken from each cow is identified by this number.

31. MILK - Each milk weight for the day is recorded to the nearest tenth. Milk weights less than 10 receive a zero as the first digit, e.g. 8.5 = 08.5

32. FAT % - Will be recorded in the Centralized Milk Testing Laboratory.

33. GRAIN FED - Record the total amount of concentrate fed per day.

34. STATUS CODES - If a change in status occurred for any cow since last day of test, an entry indicating the day of occurrence and the corresponding code to the event is expected. Space for two changes in the same period is provided, e.g. 6 16 04 = dry April 16th, and 1 03 05 = calved May 3rd.

For further explanation of status changes refer to "STATUS CHANGE CODES".

35. CURRENT TEST DATE - The date the A.M. weights were taken.

36. TEST DAY MILK YIELD - Weight of milk shipped to dairy plant on test day (bulk tank reading for two milkings)

NEW COW INFORMATION

37. Each cow to be entered on the program must be recorded with the information required. All data must be complete before a permanent record can be created.

Sire registration number is a must for all new cows as it plays an important role in the sire evaluation aspects of the Dairy Herd Improvement Program.

Dam indentification will insure the automatic updating of pedigree information. Special forms which were provided on a semi-annual basis for updating of cow and dam pedigree information should no longer be required.

For entry status, please refer to "ENTRY STATUS CODES".

For new cows requiring a status change, please refer to "STATUS CHANGE CODE".

PRICE AND FEED DATA (based on last test data)

38. FORAGE - The quality and amount of forage fed is keyed to voluntary intake.

39. MILK PRICING - Net price of milk, average fat test and fat differential received by the dairyman.

This information provides a current guide to cost of production and profit through:

- total feed cost
- income on milk produced
- income over feed costs

40. FORAGE CODES (voluntary intake)
    1. Fair 1½% of body weight
    2. Good 2% of body weight
    3. Excellent 2½% or more of body weight
    4. Energy intake estimated from laboratory results.

41. GRAIN CODES (value based on energy level)
    1. Excellent
    2. Good
    3. Fair
    4. Poor

SPECIAL MANAGEMENT MESSAGES

With every herd report two lists of Special Management messages are produced:

- herd management messages
- cow management messages

The purpose of the Special Management messages is three-fold:

1. to alert Data Control staff of potential errors related to production, breeding and feeding.
2. to alert the dairymen to individual cow or herd situations which require adjustments in management practices.
3. to identify herd or cow production levels that are exceptionally high and compliment excellent management practices.

The Special Management messages are intended to focus attention on information that is already reported on the herd reports; they are useful to the D.H.I Technician in assisting herd owners in the interpretation of HERD REPORTS.

XI. APPENDIX 4

HERD NO.	MB NO.	MONTH	PRODUCTION											
73D0616	330528	7903	20520	19351	19789	18786	16789	18078	18767	20080	17126	11186	11010
		7903	44.1	44.0	43.9	43.6	42.8	44.6	45.1	44.8	39.5	31.0	31.0
		7903	83.0	84.0	83.0	83.0	84.0	87.0	86.0	84.0	79.0	73.0	83.0
73D0618	246598	7903	35574	33750	38865	37228	37644	40812	37160	34044	34641	36968	39472
		7903	64.6	65.7	65.7	63.5	64.2	66.3	71.3	75.5	75.6	76.8	77.0
		7903	97.0	95.0	93.0	91.0	92.0	90.0	80.0	73.0	77.0	82.0	85.0
73D0621	334308	7903	43586	39392	40547	34538	32597	33126	31984	32022	33994	35059	35831
		7903	65.8	69.4	70.5	70.9	70.3	70.8	68.8	62.3	60.0	60.0	60.0
		7903	92.0	88.0	81.0	73.0	80.0	84.0	86.0	86.0	88.0	90.0	91.0
73D0623	107188	7903	14572	13207	15214	15585	15429	17127	20529	25428	29182	25156	22002
		7903	44.0	44.6	44.6	44.1	44.0	44.3	44.9	45.0	44.6	42.8	41.2
		7903	61.0	64.0	71.0	76.0	77.0	78.0	83.0	89.0	94.0	83.0	75.0
73D0625	325938	7903		29606	30764	28652	25297	28212	28664	34732	36438	35275	34890
		7903		57.0	55.8	55.4	56.9	55.5	56.2	58.8	59.3	59.0	60.0
		7903		70.0	71.0	73.0	73.0	75.0	78.0	86.0	84.0	84.0	84.0
73D0626	367388	7903		22692	23091	21416	18515	17005	17066	18083	19088	20659	22661
		7903		43.3	44.1	44.0	42.8	41.2	40.1	39.6	38.3	38.0	38.0
		7903		79.0	74.0	73.0	72.0	70.0	80.0	88.0	90.0	84.0	81.0
73D0630	160388	7903	13501	11573	13914	14122	14883	15452	15972	17928	18821	19093	15509
		7903	31.7	31.1	30.5	31.1	32.0	32.0	32.0	32.2	32.6	33.2	33.8
		7903	74.0	77.0	87.0	88.0	92.0	89.0	88.0	88.0	88.0	91.0	78.0
73D0631	358058	7903	47876	43129	49710	50314	46021	42699	39601	40684	41243	41487	42793
		7903	85.1	85.7	85.9	84.9	83.0	80.3	76.3	75.1	74.8	74.2	75.2
		7903	81.0	81.0	82.0	82.0	78.0	75.0	80.0	81.0	81.0	86.0	86.0
73D0632	195368	7903	5664	5214	6115	6534	6845	8273	9436	9511	8685	7448	6865
		7903	16.8	17.5	17.0	17.0	17.0	17.0	17.0	16.8	16.7	16.4	16.1
		7903	63.0	70.0	79.0	84.0	82.0	88.0	93.0	85.0	71.0	67.0	68.0
73D0634	237789	7903	18788	14624	16395	17109	18554	22426	23469	23061	20870	17600	17345
		7903	41.4	35.4	35.9	38.9	43.5	45.8	46.9	45.3	42.6	41.6	41.8
		7903	91.0	92.0	91.0	89.0	90.0	92.0	90.0	85.0	82.0	75.0	72.0
73D0636	376128	7903	29107	27797	34907	36935	37365	32429	29190	30928	32532	32290	35904
		7903	58.3	60.6	63.1	64.2	66.2	65.5	66.4	67.0	66.4	66.0	67.6
		7903	89.0	90.0	89.0	88.0	87.0	76.0	72.0	75.0	80.0	81.0	84.0
73D0637	359628	7903	21565	24360	28983	29959	27930	28729	29596	33204	37661	32861	24882
		7903	56.2	58.8	59.1	59.6	62.7	64.9	66.2	66.6	66.4	60.2	52.3
		7903	73.0	80.0	81.0	80.0	78.0	81.0	82.0	84.0	83.0	82.0	73.0
73D0639	327048	7903	8359	7588	7566	6411	7053	8549	9747	11293	12105	12415	12637
		7903	23.6	24.0	24.0	24.2	25.0	25.0	25.0	24.8	24.5	24.8	26.0
		7903	84.0	81.0	77.0	72.0	79.0	92.0	96.0	96.0	88.0	83.0	81.0

XII. APPENDIX 5

THE COMPLEX STAGE OF LACTATION MODEL

The following pages outline the coefficients to be used in predicting milk with the Complex Stage-of-Lactation model. The functional relationship hypothesized is as follows:

Y = the predicted production for a given herd
X1 = the number of cows-in-milk from 0 - 41 days
X2 = the number of cows-in-milk from 41 - 80 days
X3 = the number of cows-in-milk from 81 - 150 days
X4 = the number of cows-in-milk from 151 - 305 days
X5 = the number of cows-in-milk for 306+ days
X6 = the number of dry cows in the herd

By multiplying predicted production by the number of herds on DHI and adding this to the predicted production for herds not enrolled on the DHI program total milk production for a given category can be determined. Multiplying this figure by a weighted delivery coefficient calculates total milk deliveries for the category. Summing over categories allows total milk deliveries to be calculated.

TABLE A5.1

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING NOVEMBER MILK WITH NOVEMBER'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4284.0	1250.9***	815.8**	891.4***	478.6***	196.6	117.9	.95	2.16++
		(176.3)	(232.9)	(134.1)	(100.4)	(167.2)	(128.4)		
GE75/77	-11603.6	1060.4	-128.5	223.0	1741.7***	-1546.3	582.0*	.57	2.32++
		(1222.4)	(764.5)	(928.0)	(519.8)	(1251.0)	(337.2)		
GE78/79	-2058.3	639.7**	479.9**	563.7***	516.4***	401.7	165.9	.84	2.38+
		(345.3)	(270.7)	(147.9)	(126.0)	(324.8)	(203.2)		
I<10200	-229.5	76.7	-527.2**	1249.8***	405.4**	94.8	-34.0	.90	1.89+
		(495.3)	(268.2)	(213.5)	(152.3)	(434.5)	(272.9)		
I>10200	5955.1	1368.8***	368.2**	520.8***	86.2	154.5	-219.7	.90	2.31+
		(393.8)	(182.9)	(117.0)	(78.8)	(228.0)	(122.8)		

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.2

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING DECEMBER MILK WITH NOVEMBER'S LACTATION STAGE

PRODUCER				ESTIMATED COEFFICIENTS[1]					
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-5255.5	1391.89**	867.3***	817.7***	468.1***	146.9	168.4	.94	2.03++
		(200.0)	(252.5)	(151.9)	(113.8)	(189.4)	(145.4)		
GE75/77	-10636.8	992.9	216.2	192.9	1709.1***	-1255.9	468.1*	.58	2.26++
		(1184.2)	(740.7)	(899.0)	(503.6)	(1211.8)	(326.6)		
GE78/79	-2908.0	734.7**	262.9	656.6***	626.1***	468.2*	118.0	.85	1.86++
		(378.6)	(296.9)	(162.1)	(138.1)	(356.2)	(222.8)		
I<10200	-4693.6	183.1	-760.4**	1171.2***	484.0**	338.0	649.2*	.81	1.41+
		(734.4)	(397.6)	(316.6)	(225.7)	(644.2)	(404.6)		
I>10200	5281.5	1796.2***	223.5	407.9***	126.8*	217.8	-55.8	.89	2.62+
		(434.3)	(201.7)	(129.0)	(86.9)	(251.4)	(135.5)		

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.3

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING JANUARY MILK WITH NOVEMBER'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-5454.2	1526.7*** (219.2)	893.0** (277.2)	768.0*** (166.8)	451.8*** (124.9)	158.0 (207.9)	211.5* (159.6)	.93	1.85++
GE75/77	-7149.2	813.1 (1046.6)	399.4 (654.6)	132.5 (794.5)	1580.7*** (445.1)	-673.6 (1071.0)	313.2* (288.7)	.60	2.06++
GE78/79	-1978.7	573.0* (339.6)	248.6** (266.3)	647.2*** (145.4)	548.9*** (123.9)	578.0* (319.4)	275.2 (199.9)	.82	1.71++
I<10200	-5853.7	80.4 (751.7)	-723.8* (407.0)	1247.0*** (324.0)	486.5** (231.1)	561.9 (659.4)	813.6** (414.2)	.82	1.62+
I>10200	5730.6	1589.3*** (492.8)	310.8** (228.9)	260.4* (146.4)	176.1* (98.6)	138.2 (285.3)	62.6 (153.7)	.85	2.48+

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.4

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING FEBRUARY MILK WITH NOVEMBER'S LACTATION STAGE

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4273.8	1530.1*** (197.9)	759.0*** (250.4)	652.0*** (150.6)	432.3*** (112.8)	121.0 (187.8)	125.3 (144.2)	.93	1.74++
GE75/77	-4828.5	525.3 (846.0)	360.7 (529.2)	230.2 (642.3)	1340.1*** (359.8)	-132.1 (865.8)	222.5 (233.4)	.62	1.93++
GE78/79	-291.8	97.1 (383.8)	110.1 (301.0)	581.5*** (164.4)	482.2*** (140.0)	513.6* (361.1)	417.4** (225.9)	.83	1.85++
I<10200	-4834.4	-97.2 (648.1)	-759.5** (350.8)	1100.4*** (279.4)	388.7** (199.2)	855.0* (568.5)	806.9** (357.1)	.84	1.95+
I>10200	5654.2	1107.3** (592.6)	456.4* (275.3)	119.1 (176.1)	200.8* (118.6)	-118.3 (343.1)	149.6 (184.9)	.78	2.22++

##

[1]	- standard errors given in parentheses
[2]	- Durbin Watson statistic at the 0.01 level
***	- coefficient significant at the 0.01 level
**	- coefficient significant at the 0.05 level
*	- coefficient significant at the 0.10 level
++	- the hypothesis of no serial correlation is accepted
+	- the test for serial correlation is inconclusive

TABLE A5.5

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING MARCH MILK WITH NOVEMBER'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4491.3	1757.6***	818.2***	730.0***	532.5***	190.1	-	.93	1.63++
		(212.1)	(275.1)	(167.3)	(120.4)	(208.7)			
GE75/77	-6822.7	698.4	234.7	512.8	1366.1***	144.6	373.1*	.66	1.93++
		(846.3)	(529.3)	(642.4)	(359.9)	(866.0)	(233.4)		
GE78/79	1795.8	-90.0	46.7	638.9***	522.9***	501.0*	490.5**	.81	1.85+
		(383.8)	(301.0)	(164.4)	(140.0)	(361.1)	(225.9)		
I<10200	-4354.1	-82.9	-960.3**	1295.4***	403.5**	936.7*	796.7**	.88	1.95+
		(624.4)	(338.0)	(269.1)	(191.9)	(547.7)	(344.0)		
I>10200	7478.3	911.6***	619.5**	122.8	135.2	-245.1	263.0	.75	1.98++
		(713.8)	(331.6)	(212.1)	(142.8)	(413.2)	(222.7)		

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.6

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING APRIL MILK WITH NOVEMBER'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4558.0	1561.0***	786.6***	640.8***	580.8***	256.5*	58.9	.94	1.51+
		(207.5)	(262.4)	(157.9)	(118.2)	(196.8)	(151.1)		
GE75/77	-4484.3	761.5	184.1	408.3	1087.1***	421.0	466.9***	.72	1.92++
		(635.4)	(397.5)	(482.4)	(270.2)	(650.3)	(175.3)		
GE78/79	3244.1	-260.7	219.3	552.7***	543.1***	224.3*	524.1**	.74	2.41+
		(463.4)	(363.4)	(198.5)	(169.1)	(436.0)	(272.8)		
I<10200	-2875.6	390.2	-940.4***	1226.9***	430.6**	416.0	624.7*	.83	1.82+
		(690.8)	(374.0)	(297.8)	(212.4)	(606.0)	(380.6)		
I>10200	9635.4	520.5	795.0***	119.8	16.1*	-185.4	172.3	.78	2.25+
		(609.8)	(283.2)	(181.1)	(122.0)	(353.0)	(190.2)		

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.7

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING MAY MILK WITH NOVEMBER'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-3962.8	1420.9***	630.4**	634.7***	664.6***	214.0	260.7*	.95	1.34+
		(190.8)	(241.3)	(145.2)	(108.7)	(181.0)	(138.9)		
GE75/77	-4616.7	733.2	163.1	647.9*	987.9***	600.8	540.8***	.76	1.80++
		(589.5)	(368.7)	(447.5)	(250.7)	(603.2)	(162.6)		
GE78/79	2870.9	-513.4	72.7	641.5***	697.4***	253.3	604.5*	.70	2.42+
		(595.1)	(466.6)	(254.9)	(217.1)	(560.0)	(350.3)		
I<10200	-5490.0	959.4	-956.1**	1305.2***	635.3**	186.9	822.4*	.78	1.76+
		(938.6)	(508.1)	(404.6)	(288.5)	(823.4)	(517.2)		
I>10200	6426.1	1250.3*	1209.3***	312.0	161.9*	-104.2	235.5	.86	2.33+
		(846.4)	(393.1)	(251.4)	(169.3)	(489.9)	(264.0)		

##

1	- standard errors given in parentheses
2	- Durbin Watson statistic at the 0.01 level
***	- coefficient significant at the 0.01 level
**	- coefficient significant at the 0.05 level
*	- coefficient significant at the 0.10 level
++	- the hypothesis of no serial correlation is accepted
+	- the test for serial correlation is inconclusive

TABLE A5.8

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING JUNE MILK WITH NOVEMBER'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS'							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R'	DW'
FLUID	-2947.6	1229.8*** (185.8)	519.0** (234.9)	717.1*** (141.3)	669.0*** (105.8)	167.5 (176.2)	255.4* (135.3)	.95	1.32+
GE75/77	-6292.6	751.6 (722.7)	-121.2 (452.1)	642.8 (548.7)	1248.1*** (307.3)	313.8 (739.6)	567.1*** (199.4)	.71	2.24++
GE78/79	2219.7	-275.2 (588.2)	-134.6 (461.2)	780.9*** (251.9)	645.4*** (214.6)	345.6 (553.4)	589.0* (346.2)	.70	2.60+
I<10200	-4850.2	954.0 (867.7)	-867.4* (481.5)	1527.9*** (381.7)	617.3** (260.5)	-	640.1 (484.3)	.84	1.95+
I>10200	5654.2	1107.3** (592.6)	456.4* (275.3)	119.1 (176.1)	200.8* (118.6)	-118.3 (343.1)	149.6 (184.9)	.78	2.22++

##

' - standard errors given in parentheses
' - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.9

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING DECEMBER MILK WITH DECEMBER'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-5594.4	694.1***	1178.9***	1055.7***	489.2***	492.6***	-25.7	.95	1.79++
		(190.9)	(182.3)	(144.1)	(79.7)	(224.2)	(131.1)		
GE75/77	-10852.2	988.6	790.8	418.1	1469.6***	-975.3	207.3	.57	1.61+
		(885.8)	(1234.8)	(956.3)	(452.8)	(1198.0)	(363.2)		
GE78/79	940.4	1431.5***	553.7**	484.3***	338.7***	51.7	59.4	.91	2.18++
		(224.2)	(275.2)	(102.4)	(119.2)	(251.0)	(130.1)		
I<10200	-3578.0	1490.0*	-448.9	484.7	403.1*	-	584.4*	.60	1.48+
		(1046.4)	(837.9)	(396.9)	(259.2)		(391.9)		
I>10200	4819.1	715.2***	650.8*	342.7**	244.4**	301.2	-99.1	.85	2.56+
		(240.8)	(403.4)	(151.9)	(114.8)	(317.1)	(168.1)		

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.10

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING JANUARY MILK WITH DECEMBER'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-5715.8	648.3*** (226.7)	1206.8*** (216.4)	1089.5*** (171.0)	410.5*** (94.7)	504.6* (266.2)	154.5 (155.6)	.94	1.65++
GE75/77	-7262.0	874.5 (763.9)	805.1 (1065.0)	422.6 (824.7)	1375.9*** (390.5)	-667.0 (1033.2)	99.9 (313.2)	.61	1.48+
GE78/79	1487.4	1421.0*** (212.6)	630.6** (280.0)	478.2*** (108.3)	262.7** (125.3)	-	200.8* (136.7)	.89	2.29++
I<10200	-4797.3	1537.7 (1119.4)	-462.2 (896.4)	499.2 (424.6)	404.8* (277.3)	-	787.4** (419.3)	.60	1.65+
I>10200	5102.7	491.6** (244.9)	927.8** (391.3)	247.0* (155.1)	265.8*** (97.5)	319.5 (320.7)	-	.83	2.53+

##

[1] - standard errors given in parentheses

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - the hypothesis of no serial correlation is accepted

+ - the test for serial correlation is inconclusive

TABLE A5.11

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING FEBRUARY MILK WITH DECEMBER'S LACTATION STAGES

PRODUCER CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
		ESTIMATED COEFFICIENTS[1]							
FLUID	-4601.5	547.7*** (213.6)	1079.9*** (204.0)	1016.3*** (161.1)	310.8*** (89.2)	527.7** (250.8)	215.6* (146.6)	.93	1.62++
GE75/77	-3900.2	617.6 (600.6)	672.0 (837.3)	266.0 (648.4)	1248.4*** (307.0)	-559.7 (812.3)	112.6 (246.2)	.65	1.51+
GE78/79	2755.0	1166.4*** (256.0)	291.1 (314.2)	416.1*** (116.9)	192.9* (136.1)	124.6 (286.6)	329.6** (148.5)	.86	2.22++
I<10200	-3891.9	1560.4* (1093.2)	-552.1 (857.5)	286.1 (425.5)	287.7 (266.2)	325.4 (807.5)	817.9** (407.6)	.61	1.91+
I>10200	4696.0	257.2 (290.8)	1046.7** (487.2)	154.5 (183.4)	259.5** (138.7)	188.2 (383.0)	101.2 (203.1)	.78	2.40+

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.12

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING MARCH MILK WITH DECEMBER'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-5035.1	580.0** (237.9)	1180.3*** (227.1)	1197.9*** (179.5)	322.3*** (99.3)	748.1*** (279.4)	190.2 (163.3)	.93	1.61++
GE75/77	-4624.2	617.5 (602.8)	607.1 (840.3)	362.4 (650.7)	1337.6*** (308.1)	-442.1 (815.3)	279.8 (247.1)	.69	1.60+
GE78/79	5591.1	1130.0*** (306.8)	-	471.3*** (140.1)	184.6 (163.1)	403.0 (328.3)	351.6** (177.9)	.81	2.14++
I<10200	-4055.0	2130.9** (1080.6)	-570.3 (847.7)	417.7 (420.6)	290.7 (263.2)	177.2 (798.3)	704.6* (403.0)	.65	1.83+
I>10200	5725.9	153.8 (341.4)	1212.5** (572.1)	183.7 (215.4)	217.0 (162.8)	177.3 (449.7)	242.1 (238.4)	.76	2.05++

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.13

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING APRIL MILK WITH DECEMBER'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4945.2	528.1** (215.6)	1098.1*** (205.9)	1105.5*** (162.7)	359.6*** (90.0)	815.6* (253.2)	208.4* (148.0)	.94	1.48+
GE75/77	-3201.7	567.7 (445.3)	460.4 (620.7)	401.8 (480.7)	1080.4*** (227.6)	-170.9 (602.2)	404.5** (182.6)	.75	1.44+
GE78/79	7565.2	1215.0*** (338.0)	-316.3 (414.9)	524.1*** (154.3)	131.8 (179.7)	628.3** (378.5)	231.8 (196.1)	.80	1.89++
I<10200	-2704.5	1988.0* (1217.6)	-570.3 (975.0)	417.7 (461.9)	290.7 (301.6)	177.2 (301.6)	704.6* (403.0)	.65	1.83+
I>10200	6727.4	93.1 (307.7)	940.1** (515.6)	385.4** (194.1)	80.8 (146.7)	373.7 (405.3)	242.4 (214.9)	.76	2.10++

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
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TABLE A5.14

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING MAY MILK WITH DECEMBER'S LACTATION STAGES

PRODUCER				ESTIMATED COEFFICIENTS[1]					
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4165.2	562.8***	931.9***	1018.2***	484.8***	576.1**	388.5***	.95	1.26+
		(198.7)	(189.7)	(149.9)	(83.0)	(233.3)	(136.4)		
GE75/77	-3123.3	565.7*	291.1	718.8*	973.6***	125.3	460.6***	.78	1.43+
		(418.8)	(583.8)	(452.1)	(214.1)	(566.4)	(171.7)		
GE78/79	9242.6	1425.7***	-666.5	566.8***	120.6*	1102.2**	185.5	.77	1.76++
		(430.0)	(527.7)	(196.3)	(228.6)	(481.4)	(249.5)		
I<10200	-4291.3	2064.0*	-419.1	529.6	477.4*	-	811.5*	.63	1.86+
		(1217.6)	(975.0)	(461.9)	(301.6)		(456.0)		
I>10200	2385.0	353.4	1479.2**	694.0**	252.0	753.3	341.9	.85	2.25+
		(424.6)	(711.3)	(267.8)	(202.4)	(559.2)	(296.5)		

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.15

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING JUNE MILK WITH DECEMBER'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-3244.6	523.9*** (196.0)	835.6*** (187.2)	919.1*** (147.9)	576.7*** (81.9)	481.9** (230.2)	325.6** (134.5)	.95	1.28+
GE75/77	-4188.5	683.7 (543.9)	148.6 (758.2)	636.4 (587.1)	1159.6*** (278.0)	163.9 (735.6)	394.1** (223.0)	.70	1.71++
GE78/79	9877.0	1694.2*** (405.6)	-590.8 (497.8)	567.2*** (185.2)	54.0 (215.6)	758.9* (454.1)	165.6 (235.3)	.79	1.79++
I<10200	-5368.7	2390.7** (1180.3)	-328.8 (945.1)	746.4* (447.7)	447.4* (292.4)	-	776.7* (442.0)	.69	1.94+
I>10200	3461.5	427.9 (477.8)	1435.3** (800.6)	514.2* (301.4)	443.8** (227.8)	421.0 (629.4)	285.7 (333.7)	.82	2.01++

##

1 - standard errors given in parentheses
2 - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
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TABLE A5.16

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING JANUARY MILK WITH JANUARY'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS^1							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW^2
FLUID	-5549.6	1059.0*** (170.9)	810.5*** (214.7)	1149.8*** (120.9)	655.4*** (70.3)	209.9 (184.6)	-289.7 (141,1)	.96	1.86++
GE75/77	-4692.5	1271.8** (576.3)	768.8** (334.2)	169.4 (365.0)	785.6*** (227.1)	-99.6 (730.0)	386.9*** (56.0)	.91	1.33+
GE78/79	-5018.1	961.1* (554.8)	1126.9** (597.3)	257.2 (521.6)	614.7** (248.3)	-273.8 (779.4)	603.7* (377.5)	.76	2.24+
I<10200	38.2	1481.6*** (289.5)	600.6** (252.4)	340.7* (218.3)	256.5** (134.7)	83.9 (270.4)	309.8** (129.5)	.89	1.95++
I>10200	4374.3	612,5*** (222.4)	717.1*** (192.0)	341.9** (135.2)	300.6*** (103.2)	347.1 (286.5)	-76.6 (151.8)	.88	2.23++

##

^{1} - standard errors given in parentheses
^{2} - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
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TABLE A5.17

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING FEBRUARY MILK WITH JANUARY'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4599.9	945.5*** (167.6)	703.7*** (210.4)	1079.9*** (118.5)	534.8*** (68.9)	148.6 (181.0)	-149.1 (138.3)	.95	1.75++
GE75/77	-1617.7	916.0* (540.2)	613.6** (313.2)	183.8 (342.1)	788.9*** (212.9)	-249.8 (684.2)	297.2*** (52.4)	.88	1.60+
GE78/79	-4401.8	845.6* (553.5)	1124.7** (595.8)	189.7 (520.4)	459.6* (247.7)	-104.6 (777.5)	703.5** (376.6)	.71	2.34+
I<10200	236.5	1343.7*** (260.8)	182.8 (227.4)	294.7* (196.7)	257.9** (121.3)	105.3 (243.7)	455.1*** (116.7)	.89	1.53+
I>10200	4372.7	623.5** (287.2)	501.1** (247.9)	324.7** (174.6)	166.4 (133.3)	334.5 (369.9)	125.3 (196.0)	.80	2.26+

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
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** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
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TABLE A5.18

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING MARCH MILK WITH JANUARY'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-5061.8	987.7***	654.7***	1307.1***	563.4***	239.2	-124.0	.95	1.75++
		(194.3)	(244.0)	(137.4)	(79.8)	(209.8)	(160.3)		
GE75/77	436.1	455.2	699.7**	434.0	863.1***	-143.2	324.7***	.90	1.60+
		(524.6)	(304.2)	(332.3)	(206.8)	(664.5)	(50.9)		
GE78/79	-4283.3	1019.9*	1062.4*	-	571.8**	155.0	712.2*	.69	2.46+
		(567.7)	(614.8)		(229.6)	(757.0)	(384.7)		
I<10200	1819.4	1390.3***	105.9	173.1	316.1**	311.3	531.9***	.88	1.84++
		(296.3)	(258.3)	(223.4)	(137.8)	(276.8)	(132.6)		
I>10200	5656.8	826.6**	368.4	384.9**	120.2	235.4	199.8	.80	1.88++
		(330.2)	(285.1)	(200.8)	(153.3)	(425.4)	(225.3)		

##

[1] - standard errors given in parentheses

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

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+ - the test for serial correlation is inconclusive

TABLE A5.19

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING APRIL MILK WITH JANUARY'S LACTATION STAGES

PRODUCER CATEGORY	INTERCEPT	ESTIMATED COEFFICIENTS' X1	X2	X3	X4	X5	X6	R'	DW'
FLUID	-4830.0	962.3*** (175.2)	521.7** (220.0)	1228.5*** (123.9)	551.4*** (72.0)	353.0* (189.3)	-44.0 (144.6)	.96	1.65++
GE75/77	2543.8	186.3 (439.9)	707.0*** (254.0)	572.5** (269.2)	772.9*** (158.1)	-	235.4*** (41.7)	.89	1.51+
GE78/79	-3184.2	743.7* (486.0)	955.2* (526.3)	-	722.7*** (196.5)	-203.8 (648.0)	550.1* (329.3)	.75	2.40+
I<10200	3112.6	1425.1*** (358.7)	211.7** (312.8)	122.6 (270.5)	267.9* (166.9)	542.9* (335.1)	445.6*** (160.5)	.83	2.09++
I>10200	7157.0	860.0*** (228.7)	182.6 (213.9)	545.3*** (148.0)	86.5 (100.6)	214.3 (319.2)	-	.84	1.90++

##

' - standard errors given in parentheses
' - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
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+ - the test for serial correlation is inconclusive

V

TABLE A5.20

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING MAY MILK WITH JANUARY'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4095.8	978.8*** (153.9)	455.1** (193.3)	1112.6*** (108.8)	613.6*** (63.3)	352.2** (166.2)	131.9 (127.0)	.97	1.39+
GE75/77	3660.1	-120.2 (495.9)	755.0*** (287.6)	712.3** (314.0)	835.2*** (195.4)	147.6 (628.0)	209.5*** (48.1)	.87	1.85++
GE78/79	-4526.7	683.4 (517.8)	1115.5** (560.8)	-	983.1*** (209.4)	-481.9 (690.5)	641.7* (350.9)	.80	2.53+
I<10200	3286.3	1598.0*** (424.3)	116.2 (378.6)	-	318.9* (209.8)	991.2** (414.5)	488.7** (200.3)	.80	2.06++
I>10200	3557.8	1225.2*** (387.8)	378.6 (334.8)	915.3*** (235.8)	214.1 (180.0)	426.4 (499.6)	147.3 (264.6)	.88	2.29+

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
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TABLE A5.21

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING JUNE MILK WITH JANUARY'S LACTATION STAGES

PRODUCER CATEGORY	INTERCEPT	ESTIMATED COEFFICIENTS[1] X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-2886.7	952.0*** (153.8)	440.6** (193.2)	952.0*** (108.8)	702.5*** (63.2)	338.5** (166.1)	30.1 (127.0)	.97	1.29+
GE75/77	2369.7	-	763.2*** (237.1)	503.8** (210.5)	825.8*** (160.8)	543.6 (519.7)	305.3*** (37.9)	.92	1.85+
GE78/79	-3756.3	641.5 (647.1)	862.8 (696.7)	132.4 (608.4)	1029.5*** (289.6)	-579.9 (909.0)	534.2 (440.3)	.77	2.45+
I<10200	3722.8	1810.2*** (463.6)	113.2 (404.2)	-52.1 (349.6)	290.2* (215.7)	689.7* (433.1)	478.5** (207.5)	.80	1.69++
I>10200	4630.7	972.5** (483.1)	394.6 (417.1)	764.8** (293.8)	292.7 (224.2)	279.6 (622.3)	353.1 (329.7)	.83	2.39+

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
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TABLE A5.22

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING FEBRUARY MILK WITH FEBRUARY'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4626.3	852.6*** (186.8)	698.8** (183.4)	802.0*** (113.0)	599.0*** (77.7)	198.8 (200.7)	-58.5 (127.4)	.96	1.94++
GE75/77	-6171.2	936.7*** (271.7)	697.5** (324.0)	341.2 (347.1)	809.1*** (207.2)	-70.2 (503.5)	353.3*** (42.1)	.90	1.47+
GE78/79	-459.4	455.8** (218.0)	793.7*** (136.5)	536.9*** (180.4)	444.7*** (82.0)	371.5* (272.3)	140.6 (107.0)	.91	2.46+
I<10200	157.2	1278.1*** (361.6)	734.1* (423.1)	243.8 (437.3)	642.1*** (168.5)	379.2 (453.1)	-647.8* (458.6)	.82	1.58+
I>10200	1758.3	719.1*** (236.0)	766.5*** (246.0)	400.5** (173.6)	450.4*** (86.9)	207.2 (210.2)	-205.8* (150.0)	.90	2.00++

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.23

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING MARCH MILK WITH FEBRUARY'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-5168.6	863.1***	634.5***	1075.9***	656.7***	126.6	84.3	.95	1.91++
		(230.4)	(226.2)	(139.4)	(95.9)	(247.5)	(157.1)		
GE75/77	-3732.8	988.1***	654.1**	379.9	905.8***	-404.2	379.3***	.93	1.31+
		(253.3)	(302.2)	(323.7)	(193.2)	(469.6)	(39.3)		
GE78/79	1829.9	351.6	790.0***	541.5**	393.6***	429.6	323.4**	.85	2.50+
		(298.4)	(186.8)	(246.9)	(112.2)	(372.6)	(146.4)		
I<10200	617.7	1295.0***	825.7*	266.2	713.9***	498.2	-715.8	.79	1.75++
		(430.3)	(503.5)	(520.5)	(200.5)	(539.3)	(545.7)		
I>10200	1906.3	922.6***	990.9***	283.3	511.3***	117.5	-239.1	.88	1.50+
		(295.4)	(308.0)	(217.3)	(108.7)	(263.2)	(187.7)		

---

[1] - standard errors given in parentheses

[2] - Durbin Watson statistic at,the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - the hypothesis of no serial correlation is accepted

+ - the test for serial correlation is inconclusive

TABLE A5.24

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING APRIL MILK WITH FEBRUARY'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-5013.2	794.1***	641.3***	979.9***	621.4***	284.1	158.0	.95	1.76++
		(214.0)	(210.1)	(129.5)	(89.0)	(229.9)	(146.0)		
GE75/77	863.8	730.3***	574.4**	455.7*	776.3***	-488.0	281.9***	.89	1.28+
		(249.7)	(297.7)	(318.9)	(190.4)	(462.6)	(38.7)		
GE78/79	2714.3	499.1	661.1***	689.6**	318.0**	477.0	441.2**	.78	2.23++
		(373.1)	(233.6)	(308.7)	(140.3)	(465.9)	(183.1)		
I<10200	839.1	960.8**	594.1	484.5	724.9***	307.2	-519.6	.76	1.72++
		(437.8)	(512.3)	(529.5)	(204.0)	(548.6)	(555.2)		
I>10200	3888.5	618.3**	1165.2***	104.6	541.1***	188.5	-400.3**	.87	1.75+
		(279.5)	(291.5)	(205.6)	(102.9)	(249.0)	(177.6)		

##

[1] - standard errors given in parentheses

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - the hypothesis of no serial correlation is accepted

+ - the test for serial correlation is inconclusive

TABLE A5.25

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING MAY MILK WITH FEBRUARY'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4180.5	743.1*** (187.6)	752.5*** (184.2)	855.0*** (113.5)	691.9*** (78.1)	385.6* (201.5)	212.1* (128.0)	.96	1.53+
GE75/77	3691.7	544.7** (311.9)	526.7* (372.0)	432.4 (398.5)	845.3*** (237.9)	-458.1 (578.1)	256.4*** (48.4)	.83	1.77++
GE78/79	3129.3	-	824.7*** (304.3)	768.3** (378.4)	326.2** (186.0)	717.1 (615.3)	545.1** (243.8)	.72	2.09++
I<10200	-584.6	870.2* (548.4)	594.1 (641.7)	845.1 (663.3)	833.8*** (255.5)	207.5 (687.2)	-287.7 (695.4)	.73	1.81++
I>10200	984.1	481.3 (412.1)	1915.4*** (429.7)	60.5 (303.1)	927.5*** (151.7)	200.3 (367.1)	-474.4** (261.8)	.90	2.11++

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at, the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.26

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING JUNE MILK WITH FEBRUARY'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS'							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R'	DW'
FLUID	-2891.7	833.4*** (176.3)	730.5** (173.1)	687.1*** (106.7)	732.0*** (73.4)	458.8** (189.4)	76.3 (120.3)	.97	1.46+
GE75/77	3819.5	393.0* (266.5)	548.5* (319.1)	286.9 (341.9)	818.0*** (198.8)	-	358.2*** (41.1)	.90	1.68++
GE78/79	2847.3	155.3 (509.6)	844.1*** (319.1)	754.5** (421.7)	388.3** (191.6)	650.7 (636.4)	404.9* (250.1)	.71	2.00++
I<10200	-549.8	1031.4*** (552.9)	391.7 (647.0)	745.6 (668.8)	936.1*** (257.6)	242.8 (692.9)	-354.7 (701.2)	.76	1.89++
I>10200	1921.6	655.3 (505.3)	1571.2*** (526.9)	93.73 (371.7)	847.4*** (186.0)	120.2 (450.2)	-176.2 (321.1)	.86	2.02++

##

' - standard errors given in parentheses
' - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.27

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING MARCH MILK WITH MARCH'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4791.1	1374.3***	976.5***	854.3***	645.1***	365.7*	-290.5*	.95	2.56+
		(272.8)	(204.1)	(118.2)	(94.0)	(235.0)	(159.3)		
GE75/77	-2408.8	451.9***	1207.0***	642.8***	716.5***	-388.2	379.9***	.95	1.32+
		(158.1)	(236.4)	(167.2)	(129.5)	(330.4)	(30.5)		
GE78/79	418.8	698.8**	407.6*	785.1***	434.9***	473.0*	212.4**	.90	2.77+
		(291.6)	(257.5)	(126.5)	(100.6)	(314.4)	(108.8)		
I<10200	-2944.9	1152.4***	503.1	1646.6**	618.6***	233.4	-276.5	.81	1.64+
		(594.9)	(584.1)	(603.1)	(211.3)	(547.3)	(441.9)		
I>10200	3244.1	554.6***	738.3***	478.3**	477.5***	-45.9	-163.1	.92	1.47+
		(171.9)	(184.8)	(134.2)	(85.7)	(291.1)	(155.3)		

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[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.28

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING APRIL MILK WITH MARCH'S LACTATION STAGES

PRODUCER					ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4903.6	1321.6*** (264.9)	826.3*** (198.1)	840.3*** (114.8)	583.8*** (91.2)	486.4** (228.1)	-130.5 (154.7)	.95	2.35++
GE75/77	948.6	451.0** (187.7)	780.0*** (280.7)	611.1*** (198.5)	742.5*** (153.7)	-410.4 (392.3)	267.5*** (36.2)	.91	1.27+
GE78/79	1494.5	706.3** (376.0)	404.9 (332.0)	742.3*** (163.2)	346.4*** (129.7)	416.5* (405.5)	315.0** (140.3)	.85	2.42+
I<10200	-1809.3	796.2 (615.2)	234.8 (604.1)	1540.1** (654.8)	611.6** (218.6)	-97.2 (566.0)	63.1 (457.0)	.78	1.66+
I>10200	5086.7	551.4** (233.5)	376.5* (251.0)	355.3** (182.3)	322.6*** (116.4)	-199.3 (395.4)	90.2 (211.0)	.81	1.40+

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[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.29

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING MAY MILK WITH MARCH'S LACTATION STAGES

PRODUCER				ESTIMATED COEFFICIENTS[1]					
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4217.1	1129.9*** (245.8)	793.8*** (183.8)	807.4*** (106.5)	641.9*** (84.7)	540.5** (211.7)	42.4 (143.5)	.96	1.79++
GE75/77	2684.3	561.3*** (219.9)	512.5* (328.9)	585.6** (232.6)	870.1*** (180.1)	-502.8 (459.7)	231.6*** (42.4)	.87	1.61++
GE78/79	636.0	972.6** (516.9)	212.0 (456.5)	955.7*** (224.3)	373.5** (178.3)	693.3 (557.5)	344.5** (192.9)	.80	2.26++
I<10200	-2428.9	536.8 (785.4)	367.2 (771.2)	1577.9** (835.9)	684.4** (279.0)	-267.7 (722.6)	434.9 (583.4)	.75	1.75+
I>10200	1455.3	773.6** (352.5)	460.6 (378.9)	607.6** (275.2)	577.7*** (175.7)	-293.3 (596.9)	299.5 (318.5)	.86	2.02++

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.30

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING JUNE MILK WITH MARCH'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-3008.3	1015.3*** (236.9)	785.7*** (177.2)	668.2*** (102.6)	699.9*** (81.6)	593.3*** (204.0)	-30.6 (138.3)	.96	1.57+
GE75/77	3349.1	432.0** (201.2)	568.9** (300.9)	576.1*** (212.8)	731.7*** (164.8)	-245.3 (420.6)	347.0*** (38.8)	.91	1.94++
GE78/79	553.7	789.1* (525.4)	463.4 (464.0)	971.5*** (228.0)	446.8** (181.2)	705.8 (566.6)	194.0 (196.1)	.78	2.26++
I<10200	-2633.4	714.9 (822.0)	242.7 (807.1)	1350.3* (874.9)	851.5*** (292.0)	-236.7 (756.3)	398.4 (610.6)	.75	1.83+
I>10200	2584.1	824.6** (338.9)	606.8* (364.4)	530.5** (264.6)	683.7*** (169.0)	-281.0 (573.9)	193.4 (306.3)	.87	2.35+

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.31

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING APRIL MILK WITH APRIL'S LACTATION STAGES

PRODUCER	ESTIMATED COEFFICIENTS[1]								
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-5007.0	741.9*** (173.5)	1020.4*** (243.6)	789.9*** (108.9)	714.8*** (91.0)	246.1 (192.7)	28.1 (122.1)	.96	1.75++
GE75/77	-1219.1	647.8*** (179.5)	471.3** (185.1)	519.3*** (190.8)	917.2*** (157.7)	-116.0 (288.5)	272.6*** (33.1)	.93	1.40+
GE78/79	334.6	1029.5*** (255.7)	547.8* (317.3)	539.9*** (144.8)	435.0*** (101.8)	199.6 (307.1)	211.8* (131.5)	.88	2.43+
I<10200	1106.1	1167.0** (429.6)	232.3 (345.6)	711.1** (317.0)	438.4* (264.5)	-	-	.80	1.30+
I>10200	5199.8	808.0*** (183.4)	525.1** (203.5)	365.7*** (124.1)	361.9*** (78.4)	-52.5 (175.5)	-154.2 (106.3)	.91	2.32+

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.32

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING MAY MILK WITH APRIL'S LACTATION STAGES

PRODUCER CATEGORY	ESTIMATED COEFFICIENTS[1] INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4201.8	460.2** (175.1)	1105.1*** (245.8)	727.3*** (109.9)	720.4*** (91.8)	290.0* (194.4)	307.5** (123.3)	.96	1.57+
GE75/77	-862.8	870.8*** (200.0)	318.8* (206.2)	482.7** (212.6)	1056.2*** (175.8)	-203.7 (321.4)	221.0*** (36.9)	.91	1.66++
GE78/79	-940.2	1309.7*** (381.2)	570.0 (473.1)	632.5*** (216.0)	421.6*** (151.8)	497.5 (458.0)	282.6* (196.1)	.81	2.36++
I<10200	536.8	1448.7** (526.2)	-	860.2** (420.9)	449.6 (388.6)	-121.1 (295.1)	281.9 (454.3)	.81	1.46+
I>10200	1496.0	1107.6*** (308.7)	616.4** (342.5)	506.8** (208.9)	732.2*** (131.9)	152.4 (295.3)	-112.2 (178.8)	.92	2.46+

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.33

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING JUNE MILK WITH APRIL'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-3311.5	202.1 (169.4)	1301.2*** (237.8)	582.1*** (106.3)	714.8*** (88.8)	323.3* (188.1)	361.0*** (119.2)	.96	1.54+
GE75/77	1224.4	746.4*** (200.5)	264.8 (206.8)	571.9*** (213.2)	843.8*** (176.2)	-66.2 (322.3)	336.6*** (37.0)	.93	2.08++
GE78/79	-1703.5	1128.7*** (384.6)	869.8** (477.2)	650.8*** (217.9)	536.3*** (153.1)	586.0 (462.0)	100.3 (197.8)	.80	2.40+
I<10200	1200.2	1652.1*** (494.3)	-	670.4* (395.3)	643.2* (365.0)	-156.9 (277.2)	50.2 (426.7)	.85	1.34+
I>10200	2815.6	782.3** (364.5)	844.8** (404.4)	464.8** (246.7)	798.7*** (155.8)	465.4 (348.7)	-136.1 (211.2)	.89	2.57+

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.34

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING MAY MILK WITH MAY'S LACTATION STAGES

PRODUCER CATEGORY	INTERCEPT	ESTIMATED COEFFICIENTS[1] X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-4731.1	721.9*** (125.2)	698.7*** (186.5)	848.9*** (109.3)	757.5*** (62.0)	340.4** (168.6)	172.6* (106.3)	.97	1.36+
GE75/77	-396.4	1184.2*** (347.5)	705.1*** (155.2)	556.5*** (199.4)	648.9*** (161.4)	404.0 (337.7)	165.8*** (44.8)	.90	1.68++
GE78/79	-2717.9	684.9*** (220.6)	1322.5*** (301.0)	747.6*** (177.4)	499.9*** (158.5)	847.1** (463.5)	-71.3 (258.5)	.86	2.53+
I<10200	516.2	157.9 (370.9)	180.7 (537.3)	-	715.3** (367.8)	-117.6 (556.6)	1249.2 (1024.4)	.7580	1.58+
I>10200	-230.2	554.7*** (161.1)	1592.1*** (204.6)	471.3*** (115.3)	604.2*** (80.0)	84.0 (264.0)	191.8 (81.8)	.97	2.53+

---

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.35

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING JUNE MILK WITH MAY'S LACTATION STAGES

PRODUCER		ESTIMATED COEFFICIENTS[1]							
CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
FLUID	-3697.8	666.5*** (136.6)	747.3*** (203.5)	781.9*** (119.3)	663.1*** (67.6)	345.2* (184.0)	292.5** (116.0)	.96	1.45+
GE75/77	1605.9	1121.0*** (332.2)	573.8*** (148.4)	554.7*** (190.7)	522.9*** (154.3)	405.5 (322.8)	298.3*** (42.9)	.92	2.23++
GE78/79	-2922.4	446.8** (232.5)	1248.4*** (317.2)	879.8*** (187.0)	588.3*** (167.0)	1097.2** (488.5)	-168.7 (272.5)	.84	2.21++
I<10200	713.5	-96.3 (556.1)	121.7 (738.5)	-226.2 (735.2)	808.1* (392.3)	-298.3 (648.1)	1695.6 (1524.9)	.78	1.63+
I>10200	751.7	516.4** (281.7)	1457.6*** (350.6)	594.4*** (195.0)	574.0*** (138.0)	-	321.2** (128.5)	.91	2.18++

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A5.36

THE COMPLEX STAGE OF LACTATION MODEL

PREDICTING JUNE MILK WITH JUNE'S LACTATION STAGES

PRODUCER CATEGORY	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
		ESTIMATED COEFFICIENTS[1]							
FLUID	-3367.1	633.6***	1131.2***	647.6***	692.1***	144.9	207.2*	.96	1.86++
		(159.3)	(185.4)	(151.5)	(60.6)	(191.8)	(133.2)		
GE75/77	1381.7	714.3*	717.0***	544.5***	514.0***	713.9**	317.7***	.92	2.14++
		(527.9)	(200.1)	(145.0)	(175.2)	(346.7)	(55.1)		
GE78/79	-2350.8	800.3**	361.2	1231.1***	528.5**	1164.7**	-114.9	.83	2.24++
		(364.1)	(332.5)	(307.1)	(241.0)	(545.0)	(278.6)		
I<10200	-1385.9	-121.4	931.0**	643.1*	772.6*	-416.2	762.7*	.82	1.51+
		(571.0)	(385.5)	(390.2)	(495.1)	(553.8)	(432.7)		
I>10200	-1543.2	824.5**	537.5	862.5***	688.1***	-596.6	473.4**	.89	2.62+
		(395.3)	(463.5)	(266.4)	(198.9)	(518.2)	(185.5)		

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

XIII. APPENDIX 6

THE COMPLEX COWS IN MILK MODEL

The following pages outline the equations to be used in predicting milk with the Complex Cows-in-Milk model. Data for this model's development was obtained from the DHI Cow Master file. The functional relationship in the equation is as follows:

Y = the predicted production for a given herd
$X1$ = the number of cows-in-milk for a given herd
$X2$ = the number of dry cows in the herd

The herd categories are as follows:

FLUID - Traditional fluid producers
GE75/77 - Graduated entrants from 1975 to 1977
GE78/79 - Graduated entrants from 1978 to 1979
I<10200 - Industrial producers (less than 10200 MSQ)
I>10200 - Industrial producers (more than 10200 MSQ)

By summing over individual herds for a given category total milk production for the category can be determined. Aggregating categories gives total monthly production.

TABLE A6.1

THE COMPLEX COWS IN MILK MODEL

PREDICTING NOVEMBER MILK WITH NOVEMBER'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4776.1	681.2*** (38.3)	114.2 (143.0)	.93	2.46+
GE75/77	-11700.9	875.8*** (251.8)	281.3 (312.2)	.37	1.79++
GE78/79	-1996.6	522.5*** (68.2)	174.3 (172.9)	.83	2.42+
I<10200	-2582.0	475.2*** (113.0)	273.2* (340.6)	.61	2.14+
I>10200	4586.3	296.5*** (59.8)	-	.59	1.76+

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.2

THE COMPLEX COWS IN MILK MODEL

PREDICTING DECEMBER MILK WITH NOVEMBER'S COWS

PRODUCER		ESTIMATED COEFFICIENTS[1]			
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-5614.1	679.2*** (43.4)	321.0* (162.0)	.93	2.30+
GE75/77	-11944.7	927.0*** (237.1)	237.5 (294.0)	.42	1.76++
GE78/79	-2154.3	564.8*** (71.0)	135.9 (180.1)	.84	1.88+
I<10200	-5593.9	482.8*** (136.1)	794.7* (410.3)	.51	1.85+
I>10200	4815.1	271.7*** (78.4)	172.0 (200.4)	.61	1.89++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.3

THE COMPLEX COWS IN MILK MODEL

PREDICTING JANUARY MILK WITH NOVEMBER'S COWS

PRODUCER		ESTIMATED COEFFICIENTS[1]			
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-5696.3	686.0***	369.2**	.90	2.18++
		(47.7)	(178.3)		
GE75/77	-8949.9	905.1***	140.6	.48	1.66++
		(203.5)	(252.3)		
GE78/79	-1204.0	532.3***	247.6	.82	1.67++
		(75.8)	(192.2)		
I<10200	-7284.7	531.4***	993.8**	.56	1.93+
		(138.4)	(417.2)		
I>10200	5091.1	273.0***	229.4	.67	2.01++
		(72.6)	(185.7)		

---

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.4

THE COMPLEX COWS IN MILK MODEL

PREDICTING FEBRUARY MILK WITH NOVEMBER'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4474.3	633.5*** (44.5)	273.2* (166.2)	.90	2.19++
GE75/77	-6079.4	805.0*** (159.5)	88.0 (197.8)	.54	1.61+
GE78/79	393.4	444.9*** (71.7)	316.7* (181.8)	.80	1.74++
I<10200	-6224.9	467.0*** (128.0)	944.9** (385.9)	.54	2.11+
I>10200	4383.6	260.8*** (73.2)	232.4 (187.1)	.65	2.20++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.5

THE COMPLEX COWS IN MILK MODEL

PREDICTING MARCH MILK WITH NOVEMBER'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4729.3	736.3***	167.6	.90	2.20++
		(49.7)	(185.6)		
GE75/77	-6480.2	878.8***	202.8	.60	1.56+
		(157.7)	(195.5)		
GE78/79	2540.0	464.4***	345.7	.76	2.19++
		(83.9)	(212.9)		
I<10200	-5983.7	510.4***	966.3*	.52	2.15+
		(144.2)	(434.6)		
I>10200	5117.9	258.6***	357.9*	.62	1.91++
		(86.5)	(221.2)		

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.6

THE COMPLEX COWS IN MILK MODEL

PREDICTING APRIL MILK WITH NOVEMBER'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4631.6	713.7***	188.8	.91	2.07++
		(44.4)	(165.8)		
GE75/77	-3558.3	736.0***	319.3**	.69	1.44+
		(118.1)	(146.4)		
GE78/79	3209.2	449.7***	389.0*	.70	2.32++
		(97.7)	(247.8)		
I<10200	-3257.8	464.2***	726.3*	.47	1.93+
		(144.0)	(434.2)		
I>10200	5978.0	235.9***	290.8*	.59	1.66+
		(81.2)	(207.6)		

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.7

THE COMPLEX COWS IN MILK MODEL

PREDICTING MAY MILK WITH NOVEMBER'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4203.7	700.8*** (39.3)	378.2** (146.7)	.94	1.84++
GE75/77	-2925.2	735.0*** (108.7)	403.7*** (134.8)	.72	1.51+
GE78/79	3086.1	513.6*** (129.1)	427.6 (327.4)	.63	2.28++
I<10200	-4186.1	566.4*** (171.1)	800.9* (515.7)	.48	1.75+
I>10200	1511.3	473.8*** (118.6)	438.8* (303.2)	.70	1.86++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.8

THE COMPLEX COWS IN MILK MODEL

PREDICTING JUNE MILK WITH NOVEMBER'S COWS

PRODUCER CATEGORY	INTERCEPT	ESTIMATED COEFFICIENTS[1] X1	X2	R²	DW²
FLUID	-3455.4	674.9*** (36.9)	362.8** (137.9)	.94	1.69++
GE75/77	-3966.3	796.3*** (141.5)	343.9* (175.5)	.62	1.82++
GE78/79	3228.4	514.0*** (127.7)	393.9 (323.7)	.63	2.26++
I<10200	-4865.8	617.5*** (174.7)	772.9* (526.4)	.51	1.94+
I>10200	2635.3	518.4*** (117.6)	387.2 (300.7)	.73	2.07++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.9

THE COMPLEX COWS IN MILK MODEL

PREDICTING DECEMBER MILK WITH DECEMBER'S COWS

PRODUCER	ESTIMATED	COEFFICIENTS[1]			
CATEGORY	INTERCEPT	X1	X2	R^2	DW^2
FLUID	-5493.6	737.8*** (39.9)	64.0 (148.4)	.93	2.28++
GE75/77	-11741.5	1000.2*** (220.4)	-	.47	1.52+
GE78/79	-1568.4	555.2*** (59.9)	171.1 (154.1)	.83	2.03++
I<10200	-3020.7	469.0*** (138.7)	420.7* (313.7)	.50	1.65+
I>10200	3747.6	377.6*** (72.9)	-74.2 (177.1)	.74	2.06++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.10

THE COMPLEX COWS IN MILK MODEL

PREDICTING JANUARY MILK WITH DECEMBER'S COWS

PRODUCER CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
		ESTIMATED COEFFICIENTS[1]			
FLUID	-5562.9	711.9*** (46.7)	255.2* (173.8)	.91	2.15++
GE75/77	-8391.7	956.8*** (193.5)	-56.0 (280.6)	.53	1.36+
GE78/79	-1107.6	524.6*** (64.1)	308.1* (165.1)	.81	1.84++
I<10200	-4278.9	480.4*** (146.5)	620.6* (331.4)	.51	1.81+
I>10200	4416.0	341.1*** (72.5)	70.6 (176.2)	.74	2.13++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.11

THE COMPLEX COWS IN MILK MODEL

PREDICTING FEBRUARY MILK WITH DECEMBER'S COWS

PRODUCER		ESTIMATED COEFFICIENTS[1]			
CATEGORY	INTERCEPT	X1	X2	R^2	DW^2
FLUID	-4411.8	626.0***	310.5*	.90	2.17++
		(44.3)	(165.0)		
GE75/77	-4966.5	822.1***	-48.2	.56	1.29+
		(155.7)	(225.8)		
GE78/79	143.6	430.9***	412.3	.78	1.94+
		(61.6)	(158.4)		
I<10200	-3538.0	406.0***	639.1*	.49	2.05+
		(135.2)	(305.9)		
I>10200	4052.5	286.9***	184.8	.70	2.28+
		(77.3)	(187.7)		

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.12

THE COMPLEX COWS IN MILK MODEL

PREDICTING MARCH MILK WITH DECEMBER'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4775.4	711.3*** (49.6)	290.4* (184.6)	.90	2.24++
GE75/77	-5655.7	886.5*** (156.7)	105.7 (227.3)	.60	1.31+
GE78/79	2384.1	455.6*** (72.7)	414.1** (187.1)	.74	2.31++
I<10200	-3513.9	465.7*** (148.2)	646.2* (335.2)	.50	2.10+
I>10200	4726.4	280.4*** (90.7)	327.2* (220.4)	.68	1.91++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.13

THE COMPLEX COWS IN MILK MODEL

PREDICTING APRIL MILK WITH DECEMBER'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4672.1	695.8*** (43.7)	280.1* (162.8)	.92	2.11++
GE75/77	-3850.9	750.8*** (115.4)	275.1+ (167.4)	.68	1.16+
GE78/79	3294.5	486.4*** (83.5)	282.7* (214.9)	.68	2.33++
I<10200	-1804.5	463.9*** (140.7)	473.1* (318.2)	.50	1.82+
I>10200	5438.5	270.7*** (84.1)	232.5 (204.4)	.66	1.63+

###

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.14

THE COMPLEX COWS IN MILK MODEL

PREDICTING MAY MILK WITH DECEMBER'S COWS

PRODUCER CATEGORY	ESTIMATED COEFFICIENTS[1] INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4165.9	688.3*** (37.9)	440.5*** (140.9)	.94	1.84++
GE75/77	-3585.2	754.3*** (105.5)	367.7** (153.0)	.73	1.18+
GE78/79	3434.0	570.9*** (109.5)	228.1 (281.8)	.61	2.31++
I<10200	-3028.3	583.4*** (162.6)	548.6* (367.8)	.53	1.59+
I>10200	671.4	538.5*** (118.7)	317.8 (288.4)	.77	1.82++

###

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.15

THE COMPLEX COWS IN MILK MODEL

PREDICTING JUNE MILK WITH DECEMBER'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-3368.5	679.4***	346.3**	.95	1.64++
		(35.5)	(132.3)		
GE75/77	-4367.6	829.5***	254.4	.65	1.54+
		(136.5)	(197.9)		
GE78/79	3578.4	553.4***	255.9	.61	2.30++
		(108.8)	(280.1)		
I<10200	-3754.2	647.9***	513.9*	.57	1.80+
		(163.8)	(370.5)		
I>10200	2077.2	550.7***	356.9	.78	2.04++
		(119.5)	(290.2)		

###

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.16

THE COMPLEX COWS IN MILK MODEL

PREDICTING JANUARY MILK WITH JANUARY'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-5017.1	794.2*** (41.3)	-187.2 (172.2)	.94	2.28++
GE75/77	-4563.50	639.8*** (100.4)	432.6*** (46.3)	.89	1.38+
GE78/79	-1997.1	538.5*** (56.0)	357.8*** (134.3)	.82	1.96++
I<10200	-1490.3	463.7*** (115.1)	395.2 (336.6)	.62	1.97++
I>10200	4122.4	407.0*** (62.9)	-114.2 (152.2)	.81	2.06++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.17

THE COMPLEX COWS IN MILK MODEL

PREDICTING FEBRUARY MILK WITH JANUARY'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-3997.7	693.8*** (41.0)	-48.6 (171.3)	.92	2.31++
GE75/77	-1919.8	574.2*** (93.2)	336.3*** (43.0)	.86	1.55+
GE78/79	-894.4	451.2*** (53.6)	437.3*** (128.5)	.80	1.97++
I<10200	-988.7	373.2*** (111.6)	497.4* (326.2)	.57	2.05++
I>10200	3838.0	317.0*** (74.4)	106.4 (179.9)	.72	2.18++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.18

THE COMPLEX COWS IN MILK MODEL

PREDICTING MARCH MILK WITH JANUARY'S COWS

PRODUCER CATEGORY		ESTIMATED COEFFICIENTS[1]			
	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4335.0	762.8*** (29.4)	-	.92	2.40+
GE75/77	-426.1	632.7*** (90.6)	351.0*** (41.8)	.89	1.42+
GE78/79	865.2	473.7*** (60.9)	492.4*** (145.6)	.78	2.31++
I<10200	-573.2	426.4*** (122.7)	474.6 (358.7)	.57	2.15+
I>10200	4429.1	315.3*** (00.0)	234.0 (000.0)	.69	1.83++

###

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.19

THE COMPLEX COWS IN MILK MODEL

PREDICTING APRIL MILK WITH JANUARY'S COWS

PRODUCER		ESTIMATED COEFFICIENTS[1]			
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4247.5	735.9***	43.7	.93	2.25++
		(41.9)	(174.7)		
GE75/77	1526.30	604.5***	249.0***	.87	1.32+
		(79.3)	(36.6)		
GE78/79	1655.0	492.5***	409.9**	.72	2.33++
		(70.3)	(168.4)		
I<10200	633.7	444.3***	277.5*	.61	1.96+
		(111.3)	(325.5)		
I>10200	5075.6	328.0***	74.3	.69	1.65+
		(80.8)	(195.5)		

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.20

THE COMPLEX COWS IN MILK MODEL

PREDICTING MAY MILK WITH JANUARY'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-3815.9	730.0***	209.1*	.95	1.91++
		(35.8)	(149.5)		
GE75/77	2399.7	644.0***	215.1***	.84	1.55+
		(89.4)	(41.3)		
GE78/79	1748.6	563.4***	408.8*	.64	2.33++
		(95.1)	(228.0)		
I<10200	159.5	558.2***	274.6	.64	1.83+
		(127.3)	(372.4)		
I>10200	483.4	573.1***	222.3	.78	1.83++
		(115.8)	(280.2)		

---

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.21

THE COMPLEX COWS IN MILK MODEL

PREDICTING JUNE MILK WITH JANUARY'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-2944.3	723.8*** (32.9)	93.3 (137.5)	.96	1.58+
GE75/77	2128.2	612.9*** (79.2)	318.3*** (36.6)	.90	1.48+
GE78/79	1965.7	548.2*** (94.9)	421.4* (227.3)	.63	2.34++
I<10200	-107.1	596.5*** (133.3)	245.7 (389.7)	.65	2.00++
I>10200	2188.4	528.2*** (119.4)	422.7* (288.9)	.78	2.08++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.22

THE COMPLEX COWS IN MILK MODEL

PREDICTING FEBRUARY MILK WITH FEBRUARY'S COWS

PRODUCER		ESTIMATED COEFFICIENTS[1]			
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4044.8	702.3*** (31.3)	-162.5 (134.4)	.94	2.14++
GE75/77	-5128.8	642.6*** (85.7)	330.3*** (38.3)	.89	1.36+
GE78/79	1965.2	468.7*** (60.1)	-130.4 (114.7)	.86	2.27++
I<10200	-1705.9	537.4*** (48.9)	190.3* (101.3)	.88	2.55+
I>10200	-10.2	601.5*** (136.9)	-439.1 (432.3)	.67	1.62+

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.23

THE COMPLEX COWS IN MILK MODEL

PREDICTING MARCH MILK WITH FEBRUARY'S COWS

PRODUCER CATEGORY	ESTIMATED COEFFICIENTS[1] INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4440.7	758.0*** (38.4)	-48.3 (165.0)	.93	2.20++
GE75/77	-2848.0	675.5*** (85.9)	353.4*** (38.3)	.89	1.22+
GE78/79	2364.1	494.7*** (80.9)	-80.9 (154.5)	.80	1.83++
I<10200	436.9	506.6*** (64.9)	373.0** (134.2)	.82	2.73+
I>10200	281.9	668.2*** (148.9)	-492.1 (470.2)	.68	1.59+

###

[1]	- standard errors given in parentheses.
[2]	- Durbin Watson statistic at the 0.01 level
***	- coefficient significant at the 0.01 level
**	- coefficient significant at the 0.05 level
*	- coefficient significant at the 0.10 level
++	- no serial correlation is present
+	- the test for serial correlation is inconclusive

TABLE A6.24

THE COMPLEX COWS IN MILK MODEL

PREDICTING APRIL MILK WITH FEBRUARY'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW^2
FLUID	-4381.5	720.4***	55.4	.94	2.06++
		(34.5)	(148.3)		
GE75/77	822.0	594.6***	265.5***	.86	1.29+
		(83.3)	(37.1)		
GE78/79	3513.3	461.6***	-137.2	.78	1.85++
		(77.2)	(147.4)		
I<10200	1200.5	460.2***	498.6**	.76	2.47+
		(79.3)	(164.2)		
I>10200	1048.9	650.5***	-506.4	.71	1.50+
		(134.3)	(424.0)		

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.25

THE COMPLEX COWS IN MILK MODEL

PREDICTING MAY MILK WITH FEBRUARY'S COWS

PRODUCER CATEGORY	ESTIMATED COEFFICIENTS[1] INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-3837.2	727.5*** (29.1)	156.0 (125.2)	.96	1.70++
GE75/77	2982.4	595.2*** (100.3)	243.2*** (44.7)	.80	1.63+
GE78/79	-1549.7	727.5*** (84.3)	-	.81	2.03++
I<10200	1061.5	504.1*** (109.6)	597.7** (226.8)	.67	2.37+
I>10200	386.1	756.0*** (162.8)	-457.6 (513.9)	.71	1.71+

###

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.26

THE COMPLEX COWS IN MILK MODEL

PREDICTING JUNE MILK WITH FEBRUARY'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-2949.7	717.7***	52.3	.96	1.41+
		(26.5)	(113.8)		
GE75/77	3034.1	560.1***	346.9***	.88	1.58+
		(87.0)	(38.8)		
GE78/79	241.2	673.0***	189.6	.80	2.10++
		(128.4)	(245.0)		
I<10200	1005.7	545.3***	460.0*	.68	2.49+
		(107.7)	(223.0)		
I>10200	-87.8	802.7***	-484.9	.72	1.73+
		(169.0)	(533.4)		

###

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.27

THE COMPLEX COWS IN MILK MODEL

PREDICTING MARCH MILK WITH MARCH'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4708.9	826.4***	-362.4**	.94	2.39++
		(38.5)	(164.1)		
GE75/77	-445.3	611.0***	369.8***	.92	1.39+
		(34.7)	(70.2)		
GE78/79	3370.9	513.6***	-258.0*	.87	1.78++
		(60.2)	(149.0)		
I<10200	-512.8	552.2***	310.7**	.86	2.89+
		(63.2)	(103.7)		
I>10200	-645.2	733.3***	-421.5	.72	1.75+
		(146.5)	(361.4)		

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.28

THE COMPLEX COWS IN MILK MODEL

PREDICTING APRIL MILK WITH MARCH'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4623.9	770.3*** (36.2)	-168.6 (154.4)	.94	2.21++
GE75/77	2402.6	555.6*** (74.2)	267.0*** (36.8)	.87	1.44+
GE78/79	4536.4	396.0*** (72.8)	-60.8 (180.1)	.76	1.48+
I<10200	575.3	498.4*** (79.1)	431.2*** (129.8)	.80	2.62+
I>10200	-26.0	619.7*** (149.3)	-128.0 (368.4)	.68	1.63+

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.29

THE COMPLEX COWS IN MILK MODEL

PREDICTING MAY MILK WITH MARCH'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4036.7	763.3*** (20.8)	-	.96	1.79++
GE75/77	3662.5	579.3*** (87.6)	236.1*** (43.3)	.82	1.76++
GE78/79	-239.0	657.8*** (109.1)	55.4 (269.9)	.82	1.93++
I<10200	288.4	556.7*** (112.5)	498.7** (184.6)	.72	2.52+
I>10200	-893.1	656.5*** (183.6)	166.6 (453.0)	.66	1.66+

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.30

THE COMPLEX COWS IN MILK MODEL

PREDICTING JUNE MILK WITH MARCH'S COWS

PRODUCER CATEGORY	ESTIMATED COEFFICIENTS[1]				
	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-3228.1	739.4*** (30.4)	-28.2 (129.6)	.96	1.54+
GE75/77	4420.9	527.9*** (75.5)	350.8*** (37.3)	.90	1.94++
GE78/79	1058.7	703.4*** (89.6)	-	.84	2.24++
I<10200	-574.9	635.5*** (108.6)	315.4* (178.2)	.73	2.58++
I>10200	-1440.5	725.6*** (188.2)	91.8 (464.5)	.68	1.87++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.31

THE COMPLEX COWS IN MILK MODEL

PREDICTING APRIL MILK WITH APRIL'S COWS

PRODUCER		ESTIMATED COEFFICIENTS[1]			
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-5488.9	763.4***	-58.6	.96	1.73++
		(30.0)	(114.3)		
GE75/77	-96.6	600.3***	270.3***	.90	1.37+
		(67.5)	(32.3)		
GE78/79	-22.0	554.8***	287.4**	.83	2.67+
		(71.6)	(133.3)		
I<10200	303.7	533.6***	77.7	.69	1.46+
		(114.0)	(317.3)		
I>10200	4791.3	409.7***	-110.9	.83	1.54+
		(52.6)	(121.8)		

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.32

THE COMPLEX COWS IN MILK MODEL

PREDICTING MAY MILK WITH APRIL'S COWS

PRODUCER		ESTIMATED COEFFICIENTS[1]			
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4607.2	722.5*** (30.3)	249.7** (115.7)	.96	1.57+
GE75/77	399.0	141.5*** (80.2)	232.5*** (38.4)	.86	1.80++
GE78/79	-468.0	614.7*** (103.4)	367.2* (192.7)	.76	2.59+
I<10200	-1000.8	586.5*** (137.4)	402.6 (382.5)	.68	1.47+
I>10200	127.8	686.3*** (79.6)	-42.3 (184.4)	.86	1.94++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.33

THE COMPLEX COWS IN MILK MODEL

PREDICTING JUNE MILK WITH APRIL'S COWS

PRODUCER CATEGORY	ESTIMATED COEFFICIENTS[1] INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-3687.9	670.9*** (30.7)	348.7*** (117.3)	.95	1.56+
GE75/77	2224.4	572.0*** (73.0)	351.3*** (35.0)	.91	2.13++
GE78/79	-1085.9	681.1*** (99.0)	175.4 (184.4)	.77	2.52+
I<10200	-1464.7	635.3*** (142.0)	373.9 (395.2)	.70	1.69+
I>10200	1573.6	714.3*** (80.0)	-58.9 (185.3)	.87	2.26+

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.34

THE COMPLEX COWS IN MILK MODEL

PREDICTING MAY MILK WITH MAY'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-4761.0	750.0*** (26.5)	106.3 (97.3)	.97	1.38+
GE75/77	-249.9	665.7*** (76.0)	193.6*** (39.5)	.88	1.74++
GE78/79	-1068.8	702.1*** (95.9)	-42.1 (276.8)	.80	2.49+
I<10200	-1228.6	590.7* (300.5)	271.2 (1172.8)	.69	1.66+
I>10200	-244.9	668.7*** (61.9)	131.6 (124.0)	.90	2.54+

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.35

THE COMPLEX COWS IN MILK MODEL

PREDICTING JUNE MILK WITH MAY'S COWS

PRODUCER		ESTIMATED COEFFICIENTS[1]			
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-3785.2	687.9*** (28.3)	250.7** (104.0)	.96	1.43+
GE75/77	1947.5	581.3*** (71.9)	328.5*** (37.3)	.91	2.23++
GE78/79	-629.4	703.7*** (97.8)	-120.9 (282.3)	.79	2.18++
I<10200	-1429.4	572.0* (324.7)	468.8 (1267.1)	.68	1.95+
I>10200	1154.6	647.3*** (76.0)	251.3* (152.3)	.85	2.57+

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A6.36

THE COMPLEX COWS IN MILK MODEL

PREDICTING JUNE MILK WITH JUNE'S COWS

PRODUCER	ESTIMATED COEFFICIENTS[1]				
CATEGORY	INTERCEPT	X1	X2	R^2	DW[2]
FLUID	-3541.2	682.7*** (31.9)	233.2* (117.4)	.95	1.78++
GE75/77	1235.2	594.0*** (65.8)	326.5*** (35.7)	.92	2.15++
GE78/79	-353.4	669.3*** (69.9)	-	.79	2.16++
I<10200	-1303.0	508.3*** (150.3)	788.5* (413.5)	.71	1.48+
I>10200	-1175.3	677.8*** (119.5)	321.2* (188.9)	.82	2.68+

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

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XIV. APPENDIX 7

THE SIMPLIFIED STAGE OF LACTATION MODEL

The following pages outline the coefficients to be used in predicting milk with the Simplified Stage-of-Lactation model. The functional relationship hypothesized is as follows:

Y = the predicted production for a given herd
X1 = the number of cows-in-milk from 0 - 41 days
X2 = the number of cows-in-milk from 41 - 80 days
X3 = the number of cows-in-milk from 81 - 150 days
X4 = the number of cows-in-milk from 151 - 305 days
X5 = the number of cows-in-milk for 306+ days
X6 = the number of dry cows in the herd

Herd categories are dispensed with in the use of this model. By multiplying predicted production by the number of herds on DHI and adding this to the predicted production for herds not enrolled on the DHI program total milk production in Alberta can be determined. Multiplying this figure by a weighted delivery coefficient calculates total milk deliveries.

TABLE A7.1

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR NOVEMBER

PREDICTED MONTH	INTERCEPT	ESTIMATED COEFFICIENTS[1] X1	X2	X3	X4	X5	X6	R^2	DW[2]
NOVEMBER	-7310.8	1802.1*** (349.9)	-	820.4*** (231.4)	868.9*** (165.2)	-279.6 (336.3)	107.5 (268.8)	.81	1.99++
DECEMBER	-9363.3	1843.6 (392.3)	77.7 (399.0)	854.8*** (240.6)	875.8*** (163.8)	-338.8 (333.0)	372.6 (273.1)	.84	2.02++
JANUARY	-10369.0	1843.9*** (345.3)	53.8 (270.7)	936.6*** (147.9)	800.3*** (126.0)	-172.4 (324.8)	577.0** (203.2)	.87	1.94++
FEBRUARY	-8758.9	1693.0*** (274.7)	-	873.2*** (181.7)	675.7*** (129.7)	-58.1 (264.1)	538.4** (211.0)	.88	1.92++

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A7.2

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR NOVEMBER

PREDICTED		ESTIMATED COEFFICIENTS[1]							
MONTH	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
MARCH	-8844.7	1860.0*** (283.7)	-	899.9*** (195.5)	698.0*** (136.0)	-	571.6** (225.9)	.88	1.95++
APRIL	-7590.9	1647.8*** (283.0)	80.4 (287.8)	979.3*** (173.6)	588.7*** (118.2)	145.2 (240.2)	582.5*** (197.0)	.91	2.00++
MAY	-6382.3	1423.0*** (345.3)	51.6 (270.7)	976.9*** (147.9)	699.1*** (126.0)	119.9 (324.8)	614.5*** (203.2)	.91	2.06++
JUNE	-5587.3	1330.4*** (296.3)	-216.2 (301.3)	1086.0*** (181.7)	818.7*** (123.7)	46.9 (251.5)	476.8** (206.3)	.89	2.11++

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A7.3

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR DECEMBER

PREDICTED		ESTIMATED COEFFICIENTS[1]							
MONTH	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
DECEMBER	-9991.4	1213.7*** (417.0)	1037.3*** (350.4)	672.2*** (233.5)	961.7*** (169.0)	-575.3 (405.4)	358.8 (270.5)	.84	2.08++
JANUARY	-10909.4	1069.2*** (387.5)	1070.2 (325.6)	739.4*** (217.0)	856.6*** (157.1)	-434.3 (376.8)	653.7 (251.3)	.87	2.07++
FEBRUARY	-9065.5	973.8*** (336.3)	857.9*** (282.7)	692.0*** (188.4)	690.5*** (136.3)	-282.2 (327.0)	634.8 (218.2)	.88	2.05++
MARCH	-9018.8	1128.9*** (364.6)	895.8*** (306.4)	845.4*** (204.2)	699.4*** (147.8)	-158.8 (354.5)	614.7 (236.5)	.88	2.01++

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A7.4

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR DECEMBER

PREDICTED		ESTIMATED COEFFICIENTS[1]							
MONTH	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
APRIL	-7528.8	935.4*** (303.6)	971.8*** (255.1)	875.3*** (170.0)	597.9*** (123.1)	111.1 (295.2)	548.4*** (196.9)	.91	2.05++
MAY	-6082.8	885.6*** (297.8)	821.6*** (250.3)	842.4*** (166.8)	688.4*** (120.7)	150.6 (289.6)	565.8*** (193.2)	.91	2.05++
JUNE	-5238.2	888.0*** (330.9)	546.8* (278.1)	803.5*** (185.3)	867.2*** (134.2)	-88.1 (321.8)	468.6** (214.6)	.88	2.13++

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A7.5

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR JANUARY

PREDICTED	ESTIMATED COEFFICIENTS'								
MONTH	INTERCEPT	X1	X2	X3	X4	X5	X6	R'	DW'
JANUARY	-6479.6	1487.1***	868.4***	825.6***	419.6***	171.2	463.7***	.96	2.29++
		(225.4)	(222.6)	(141.6)	(100.3)	(240.6)	(40.5)		
FEBRUARY	-4900.0	1468.0***	754.6***	749.2***	360.6***	119.1	367.7***	.95	2.14++
		(220.5)	(217.8)	(138.5)	(98.1)	(235.4)	(39.6)		
MARCH	-4728.1	1736.9***	800.7***	782.8***	390.6***	184.3	367.2***	.95	1.95++
		(246.1)	(243.1)	(154.6)	(109.5)	(262.7)	(44.2)		

##

' - standard errors given in parentheses
' - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A7.6

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR JANUARY

PREDICTED		ESTIMATED COEFFICIENTS[1]							
MONTH	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
APRIL	-3973.4	1680.6***	726.0***	714.8***	442.6***	287.6	239.6***	.95	1.92++
		(233.1)	(230.3)	(146.5)	(103.8)	(248.9)	(41.9)		
MAY	-2842.2	1710.8***	572.6**	602.1***	574.8***	511.1*	194.2***	.94	2.14++
		(242.2)	(239.3)	(152.2)	(107.8)	(258.6)	(43.5)		
JUNE	-2172.8	1551.3***	414.4*	465.8***	667.3***	387.1	304.4***	.94	2.37++
		(241.5)	(238.5)	(151.7)	(107.5)	(257.8)	(43.4)		

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A7.7

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR FEBRUARY

PREDICTED		ESTIMATED COEFFICIENTS'							
MONTH	INTERCEPT	X1	X2	X3	X4	X5	X6	R'	DW'
FEBRUARY	-5781.7	871.1*** (177.9)	677.4*** (168.6)	964.3*** (121.9)	492.7*** (88.9	-	344.0*** (33.1)	.96	1.91++
MARCH	-5458.1	1036.8*** (197.7)	760.7*** (187.1)	1043.6*** (135.8)	525.9*** (97.9)	-106.3 (193.2)	354.1*** (36.6)	.95	1.81++
APRIL	-4106.1	996.3*** (186.6)	757.6*** (176.5)	952.4*** (128.2)	538.9*** (92.4)	-94.8 (182.3)	243.5*** (34.5)	.96	1.86++

##

' - standard errors given in parentheses
' - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A7.8

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR FEBRUARY

PREDICTED MONTH	ESTIMATED COEFFICIENTS[1] INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
MAY	-2248.9	895.3***	905.4***	826.9***	590.2***	89.5	212.9***	.94	2.00++
		(207.9)	(196.7)	(142.8)	(103.0)	(203.2)	(38.5)		
JUNE	-1585.9	900.7***	782.3***	617.1***	619.4***	159.5	333.9***	.94	2.17++
		(205.7)	(194.6)	(141.3)	(101.8)	(201.0)	(38.1)		

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A7.9

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR MARCH

PREDICTED	ESTIMATED COEFFICIENTS[1]								
MONTH	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
MARCH	-7013.5	1029.6*** (239.2)	1031.5*** (203.7)	818.4*** (128.6)	652.4*** (92.8)	114.2 (181.4)	334.6*** (36.7)	.96	1.81++
APRIL	-5493.0	1045.4*** (217.5)	982.1*** (185.3)	788.8*** (116.9)	609.1*** (84.4)	125.8 (165.0)	234.1*** (33.3)	.96	1.95++

---

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A7.10

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR MARCH

PREDICTED		ESTIMATED COEFFICIENTS[1]							
MONTH	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
MAY	-3396.7	1137.1***	969.3***	745.8***	584.2***	261.3	212.2***	.95	2.07++
		(232.2)	(197.9)	(124.9)	(90.2)	(176.2)	(35.6)		
JUNE	-2440.1	1081.4***	943.4***	522.8***	599.0***	309.0*	326.2***	.95	2.20++
		(219.6)	(187.0)	(118.0)	(85.2)	(166.6)	(33.7)		

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

TABLE A7.11

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR APRIL

PREDICTED	ESTIMATED COEFFICIENTS[1]								
MONTH	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
APRIL	-5484.4	601.9***	961.4***	819.5***	715.4***	174.9	264.0***	.96	1.99++
		(196.3)	(202.1)	(129.3)	(76.6)	(166.4)	(35.2)		
MAY	-3196.3	683.9***	1012.0***	833.9***	642.5***	245.8	239.1***	.95	2.06++
		(215.0)	(221.4)	(141.7)	(84.0)	(182.3)	(38.5)		
JUNE	-2442.7	536.2***	1065.3***	699.6***	603.9***	425.8*	353.5***	.95	2.18++
		(212.5)	(218.8)	(140.0)	(83.0)	(180.1)	(38.1)		

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
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+ - the test for serial correlation is inconclusive

TABLE A7.12

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR MAY

PREDICTED		ESTIMATED COEFFICIENTS[1]							
MONTH	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
MAY	-3051.0	445.7*** (146.0)	1130.1*** (224.8)	920.7*** (101.6)	602.5*** (68.2)	350.0* (205.3)	198.0*** (35.7)	.96	1.88++
JUNE	-1374.4	268.7*** (151.5)	1033.7*** (233.3)	938.4*** (105.4)	500.2*** (70.0)	351.3 (213.0)	338.8*** (37.0)	.95	2.05++

TABLE A7.13

THE SIMPLIFIED STAGE OF LACTATION MODEL FOR JUNE

PREDICTED	ESTIMATED COEFFICIENTS[1]								
MONTH	INTERCEPT	X1	X2	X3	X4	X5	X6	R^2	DW[2]
JUNE	-2648.7	919.7***	374.9***	875.3***	653.7***	219.4*	325.1***	.94	1.94++
		(240.0)	(199.7)	(159.3)	(76.6)	(215.3)	(42.1)		

##

[1] - standard errors given in parentheses
[2] - Durbin Watson statistic at the 0.01 level
*** - coefficient significant at the 0.01 level
** - coefficient significant at the 0.05 level
* - coefficient significant at the 0.10 level
++ - the hypothesis of no serial correlation is accepted
+ - the test for serial correlation is inconclusive

XV. APPENDIX 8

THE SIMPLIFIED COWS IN MILK MODEL

The following pages outline the equations to be used in predicting milk with the Simplified Cows-in-Milk model. Data for this model's development was obtained from the DHI Cow Master file. The functional relationship in the equation is as follows:

Y = the predicted production for a given DHI herd

X1 = the number of cows-in-milk for a given DHI herd

X2 = the number of dry cows in the DHI herd

Herd categories are dispensed with in the use of this model. By multiplying this predicted production by the number of herds on DHI and adding this to the predicted production for herds not enrolled on the DHI program total milk production in Alberta can be determined. Multiplying this figure by a weighted delivery coefficient calculates total milk deliveries.

TABLE A8.1

THE SIMPLIFIED COWS IN MILK MODEL FOR NOVEMBER

PREDICTED	ESTIMATED COEFFICIENTS[1]				
MONTH	INTERCEPT	X1	X2	R^2	DW[2]
NOVEMBER	-8755.9	732.6*** (74.3)	323.2 (275.6)	.77	2.26++
DECEMBER	-11025.6	753.3*** (73.9)	609.6** (274.3)	.80	2.31++
JANUARY	-12069.2	762.8*** (68.6)	772.5*** (254.5)	.84	2.25++
FEBRUARY	-10349.5	687.2*** (59.6)	695.3 (221.0)	.85	2.23++

###

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A8.2

THE SIMPLIFIED COWS IN MILK MODEL FOR NOVEMBER

PREDICTED	ESTIMATED COEFFICIENTS[1]				
MONTH	INTERCEPT	X1	X2	R^2	DW^2
MARCH	-10677.6	757.8*** (64.6)	725.1*** (239.6)	.85	2.20++
APRIL	-9297.7	712.2*** (54.2)	692.5*** (201.0)	.88	2.19++
MAY	-7071.8	706.2*** (51.5)	690.7*** (190.9)	.89	2.22++
JUNE	-5033.1	706.7*** (56.9)	500.3** (210.9)	.85	2.26++

###

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A8.3

THE SIMPLIFIED COWS IN MILK MODEL FOR DECEMBER

PREDICTED	ESTIMATED	COEFFICIENTS[1]			
MONTH	INTERCEPT	X1	X2	R^2	DW[2]
DECEMBER	-10889.1	810.7*** (77.4)	407.3 (278.9)	.81	2.23++
JANUARY	-12185.7	784.1*** (71.7)	721.6*** (258.3)	.85	2.20++
FEBRUARY	-10531.6	691.4*** (62.0)	715.9*** (223.4)	.86	2.20++
MARCH	-10868.8	768.5*** (66.8)	726.7 (240.7)	.86	2.18++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A8.4

THE SIMPLIFIED COWS IN MILK MODEL FOR DECEMBER

PREDICTED	ESTIMATED COEFFICIENTS[1]				
MONTH	INTERCEPT	X1	X2	R^2	DW[2]
APRIL	-9430.4	729.4*** (55.6)	660.4*** (200.4)	.89	2.18++
MAY	-7151.8	727.7*** (53.0)	636.2*** (190.9)	.90	2.19++
JUNE	-5051.9	720.9*** (59.4)	484.1** (213.9)	.86	2.21++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A8.5

THE SIMPLIFIED COWS IN MILK MODEL FOR JANUARY

PREDICTED	ESTIMATED COEFFICIENTS[1]				
MONTH	INTERCEPT	X1	X2	R^2	DW[2]
JANUARY	-9884.27	776.5*** (30.8)	457.4*** (43.2)	.94	1.96++
FEBRUARY	-8256.3	711.3*** (30.4)	360.6*** (42.5)	.93	1.94++
MARCH	-8448.1	787.5*** (34.0)	360.6*** (47.7)	.92	1.87++

###

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A8.6

THE SIMPLIFIED COWS IN MILK MODEL FOR JANUARY

PREDICTED	ESTIMATED COEFFICIENTS[1]				
MONTH	INTERCEPT	X1	X2	R^2	DW^2
APRIL	-7047.1	768.9*** (31.3)	235.9*** (43.8)	.92	1.87++
MAY	-4769.1	772.7*** (30.5)	196.0*** (42.8)	.92	1.96++
JUNE	-3150.3	703.8*** (29.8)	315.9** (41.7)	.92	2.06++

###

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A8.7

THE SIMPLIFIED COWS IN MILK MODEL FOR FEBRUARY

PREDICTED MONTH	ESTIMATED INTERCEPT	COEFFICIENTS[1] X1	X2	R^2	DW[2]
FEBRUARY	-7653.8	688.1*** (24.6)	337.8*** (37.3)	.94	2.02++
MARCH	-7687.2	756.7*** (27.8)	344.7*** (42.2)	.94	1.98++
APRIL	-6055.9	728.8*** (26.1)	234.1*** (39.6)	.94	2.01++
MAY	-3605.1	724.2*** (26.8)	207.5*** (40.7)	.93	2.04++
JUNE	-2307.0	665.1*** (25.5)	325.3** (38.7)	.93	2.12++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A8.8

THE SIMPLIFIED COWS IN MILK MODEL FOR MARCH

PREDICTED	ESTIMATED COEFFICIENTS[1]				
MONTH	INTERCEPT	X1	X2	R^2	DW^2
MARCH	-8555.3	791.1*** (27.6)	326.4*** (40.0)	.94	1.93++
APRIL	-6916.1	759.4*** (25.6)	225.9*** (37.0)	.94	1.97++
MAY	-4478.9	754.2*** (26.2)	202.1** (38.0)	.94	2.01++
JUNE	-3149.9	697.5*** (24.3)	309.3** (35.2)	.94	2.13++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A8.9

THE SIMPLIFIED COWS IN MILK MODEL FOR APRIL

PREDICTED	ESTIMATED COEFFICIENTS[1]				
MONTH	INTERCEPT	X1	X2	R^2	DW[2]
APRIL	-6794.1	749.4*** (24.1)	244.5*** (35.2)	.95	1.97++
MAY	-4288.3	741.2*** (25.8)	225.3*** (37.7)	.94	2.01++
JUNE	-2895.1	682.4*** (24.7)	332.5** (36.0)	.94	2.13++

###

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A8.10

THE SIMPLIFIED COWS IN MILK MODEL FOR MAY

PREDICTED	ESTIMATED COEFFICIENTS[1]				
MONTH	INTERCEPT	X1	X2	R^2	DW[2]
MAY	-4020.0	735.7*** (23.5)	181.6*** (36.9)	.95	2.08++
JUNE	-2452.5	664.3*** (25.0)	319.9*** (39.2)	.94	2.12++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

TABLE A8.11

PREDICTED ESTIMATED COEFFICIENTS[1]

THE SIMPLIFIED COWS IN MILK MODEL FOR JUNE

PREDICTED		ESTIMATED COEFFICIENTS[1]			
MONTH	INTERCEPT	X1	X2	R^2	DW[2]
JUNE	-3031.9	674.2*** (27.4)	331.4** (40.8)	.94	2.05++

##

[1] - standard errors given in parentheses.

[2] - Durbin Watson statistic at the 0.01 level

*** - coefficient significant at the 0.01 level

** - coefficient significant at the 0.05 level

* - coefficient significant at the 0.10 level

++ - no serial correlation is present

+ - the test for serial correlation is inconclusive

XVI. APPENDIX 9

COEFFICIENT CALCULATIONS FOR THE SIMPLIFIED MODELS

PRODUCTION COEFFICIENT:

Average production coefficient for Fluid category = .670

Average production coefficient for GE75/77 category = .822

Average production coefficient for GE78/79 category = 1.034

Average production coefficient for I<10200 category = .929

Average production coefficient for I>10200 category = .998

Using the breakdown of non DHI herds in June we obtain:

$$357(.670) + 88(.822) + 209(1.034) + 310(.929) + 135(.998)$$

$$= .865$$

DELIVERY COEFFICIENT

Average delivery coefficient for Fluid category = .952

Average delivery coefficient for GE75/77 category = .946

Average delivery coefficient for GE78/79 category = .934

Average delivery coefficient for I<10200 category = .943

Average delivery coefficient for I>10200 category = .830

Using the total herd breakdown for June we obtain:

$$640(.952) + 161(.946) + 310(.934) + 346(.943) + 182(.830)$$

$$= .933$$

XVII. APPENDIX 10

LIST OF HERDS FOR THE COMPLEX MODELS

Following is a list of the DHI herds used in the development of the Complex models. By using these herd numbers as a base these models can be made to form an integral part of the current DHI program of Alberta Agriculture.

Fluid Producers

53D1015 54D0273 54D0393 56D0034 56D0457 57D0188 59D0182

60D0381 61D0297 62D0084 62D0142 62D0304 63D0029 63D0037

63D0052 63D0292 63D0478 64D0042 64D0080 65D0115 65D0156

65D0448 66D0337 66D0485 67D0286 67D0303 68D0458 69D0431

70D0111 70D0177 71D0059 71D0097 71D0351 71D0465 72D0512

72D0543 72D0546 73D0555 73D0561 73D0570 73D0596 73D0611

73D0626 74D0697 74D0744 74D0746 75D0760 75D0797 75D0806

75D0825 75D0853 75D0858 75D0860 76D0904 76D0906 76D0929

76D0942 76D0970 77D1004 77D1018 77D1027 77D1034

GE 75/77 Producers

56D0091 63D0036 67D0093 68D0070 69D0004 71D0020 73D0569

73D0588 73D0614 73D0640 73D0642 74D0667 74D0675 74D0725

75D0805 75D0831 75D0855 75D0863 75D0881 76D0910 76D0933

76D0940 76D0944 76D0950 78D1148

GE 78/79 Producers

55D0161 60D0106 60D0451 67D0277 67D0345 68D0085 70D0322

73D0645 73D0656 74D0676 74D0738 74D0747 75D0771 76D0894

76D0921 76D0924 76D0954 76D0976 77D0984 77D0990 77D0996

77D0999 77D1017 77D1021 77D1075 78D1120

Industrial Producers <10200 lbs MSQ

61D0449 67D0087 73D0649 73D0652 74D0685 75D0772 76D0983

77D0988 77D1003 77D1009 77D1030 77D1047 77D1056 77D1062

77D1069

Industrial Producers >10200 lbs MSQ

58D0444 69D0250 71D0026 72D0545 72D0547 73D0602 73D0623

73D0630 73D0655 74D0678 74D0680 74D0741 75D0770 75D0787

75D0862 75D0880 76D0905 76D0968 77D1026

LIST OF HERDS IN THE SIMPLIFIED MODELS

Following is a list of the DHI herds used in the development of the Simplified models. These herds were obtained by randomly sampling 69 herds used in the development of the Complex models. Using these herd numbers as a base these models can be made to form an integral part of the current DHI program of Alberta Agriculture.

Milk Producers

54D0393 56D0034 57D0188 58D0444 60D0106 61D0297 61D0449

63D0037 63D0052 63D0292 63D0478 64D0042 66D0337 67D0087

67D0286 67D0303 69D0431 70D0322 71D0020 71D0351 72D0545

72D0547 73D0569 73D0626 73D0630 73D0642 73D0645 73D0649

73D0652 74D0675 74D0678 74D0680 74D0685 74D0738 74D0741

74D0746 75D0760 75D0770 75D0771 75D0772 75D0787 75D0806

75D0855 76D0904 76D0905 76D0906 76D0910 76D0929 76D0942

76D0944 76D0968 76D0970 76D0976 76D0983 77D0988 77D0990

77D0996 77D1003 77D1004 77D1009 77D1017 77D1018 77D1030

77D1047 77D1056 77D1062 77D1069 77D1075 78D1120